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Problems relating to the Development of Grassland.

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The article that follows was prepared mainly for the purposes of the British Economic Mission which recently visited Australia to advise on economic and developmental problems. It was also considered by the December, 1928, meeting of the Standing Committee on Agriculture and by the full meeting of the Council held during the same month.—Ed.

1. Importance of Grassland.

The grasslands are of the greatest economic importance to Australia, since they furnish the raw material for the wool, mutton, beef, and dairy industries. Practically the entire sheep and cattle population of the Commonwealth is maintained on the natural indigenous pastures. The total exports of Australia for 1926-27 amounted to £145,000,000, of which £79,000,000, rather more than half, represented animal products, including some £60,000,000 worth of wool. Grass must therefore be regarded as Australia's principal crop and outstanding source of wealth.

As only about 1 per cent. of Australia is under cultivation, either with crops or sown grasses, it follows that for many years, and in the arid regions perhaps indefinitely, the exploitation of the natural pastures must be looked to as the main source of raw material for the important pastoral industries.

2. Main Grassland Regions of Australia.

The most important factors in determining the character of the grassland regions in Australia are the type of rainfall and its incidence and the temperature during the rainy season.

Broadly speaking, there are two distinct types of rainfall characterestic of the northern and southern coasts of Australia respectively. The monsoonal type of rain, which affects the whole of Northern Australia to the Tropic of Capricorn, is tropical in character and normally occurs between November and April, a period of high average air

temperature. The Antarctic or winter type of rainfall affects the whole of the southern portion of the continent, and occurs between May and November, the coolest period of the year.

The grassland areas of these two regions are entirely different in type, the former being characterized by rapidly growing summer grasses, e.g., the various species of *Panicum* (panic grasses), *Andropogon* (blue grasses), *Astrebla* (Mitchell grasses), *Eragrostis* (or love grass), *Aristida*, &c., whilst in the latter the pasture consists of perennial forms, such as *Danthonia* (wallaby grasses), *Stipa* (spear grasses), *Themeda* (kangaroo grasses), with early ripening introduced annual species, e.g., *Bromus, Festuca, Hordeum, Erodium,* and the introduced annual clovers and trefoils.

Along the eastern and south-eastern portions of the Continent, the monsoonal and Antarctic types of rainfall overlap, gving a more or less regular and fairly heavy rainfall during the year. These areas, for the most part, were originally covered with forest, and the higher rainfall regions, i.e., 25 inches or over, are particularly well suited for the growth of European species of pasture plants—rye grass, cocksfoot, white and red clover, and the South American Paspalum. Tasmania, though situated in the winter rainfall regions, is, by its insular position, liberal rainfall, and cooler climate, specially well adapted for European herbage species.

Finally, the interior of the Continent, which lies between and outside the spheres of influence of the monsoonal and Antarctic rain areas, receives only occasional sporadic rains from either rain system, and is necessarily arid. The rainfall of this region varies from 5 to 10 inches per annum, and drought resistant forms, such as perennial salt-bushes, *Spinifex, Stipa, Eragrostis,* with certain early maturing annual species, constitute the main herbage cover. Native fodder trees such as myall, wilga, mulga, provide food for stock in dry seasons.

Any complete system of grassland research for Australia would necessarily investigate these four main grassland regions, namely:—

(1) The tropical northern area.
(2) The temperate southern area.
(3) The south-eastern region of more or less regular rainfall.
(4) The arid interior.

The southern grassland region (2), dominated by the winter rainfall, is of great economic importance, because it includes the sheep and wheat belts of South Queensland and New South Wales, Victoria, West Australia, South Australia, and Tasmania. The line of maximum concentration of sheep corresponds closely to the 18 to 20 inch line of rainfall south from the Tropic of Capricorn.

The northern grassland region (1), dominated by the summer or monsoonal rains, are of great economic importance to the cattle industries in Northern Queensland, Northern Territory, and north-west of Western Australia.

The area of more or less uniform rainfall, including the coastal and highland territory lying between Sydney and Melbourne, and the more elevated portions of the Western District of Victoria, is specially adapted to the growth of European pasture grasses for the support of an intensive dairying industry.

The arid interior, though forming one-third of the Continent, is very sparsely stocked, and much of it is unoccupied. Probably not more than 2 per cent. of the total sheep and cattle population are depastured in this arid region. The great bulk of the sheep population is maintained on country with 12 to 22 inches of rain, and in the area dominated by the winter rainfall.

3. Progress towards more Intensive Methods of Production.

Owing to the vast areas of land depastured in Australia and the comparatively small rural population, the production of animal products has necessarily been conducted on an extensive rather than on an intensive basis. Viewing the grasslands of Australia as a whole, comparatively little attention has been devoted in the past to those intensive methods of animal production which characterize the practice of older countries, namely:—

(*a*) The laying down of seeded pastures.

(*b*) The improvement of pastures by top dressing with phosphates and nitrogenous fertilizers.

(*c*) The supplementing of the pastures by the feeding of concentrates.

(*d*) The conservation of the surplus spring pasture for use when the pastures are bare.

Nevertheless, the change from extensive to intensive methods of production is making considerable headway, especially in the southern grassland region, and the rapidity with which the change is made will be determined largely by economic conditions and by the extension of demonstration and propaganda work.

(*a*) *Seeded pastures.*—A considerable area of land, namely, some 4,500,000 acres, has already been laid down in seeded pastures, especially in regions of higher rainfall, and the output of animal products in these areas has been greatly increased in consequence. Apart from the gramineous and leguminous plants commonly used in Europe for pasturage, many valuable pasture plants have been introduced and extensively used, e.g., *Paspalum dilatatum, Phalaris bulbosa, Pennisetum clandestinum* (Kikuyu grass), Sudan grass (*Andropogon sorghum*), *Trifolium subterraneum* (subterranean clover), *Lolium subulatum* (Wimmera rye grass), &c. There are large areas in the better rainfall areas of Australia where seeded pastures could be better used to intensify production.

(*b*) *Top dressing of pastures.*—During recent years, much attention has been given to the improvement of pastures by top dressing with phosphatic fertilizers, especially in the southern grassland region, and the practice of top dressing is rapidly extending. The benefits of top dressing, both as regards increased output per acre and improved health of stock, have been demonstrated by numerous experiments of the Departments of Agriculture, and the extension of this practice is largely a matter of active propaganda. There remains, however, the very important problem of determining the role of nitrogenous fertilizers in intensifying production from grass lands, especially seed pastures in the more favoured rainfall regions of Australia.

(*c*) *Concentrates and mineral supplements.*—The use of concentrates to supplement the natural pastures is not general in Australia. A limited number of dairymen follow this practice, and the supplementing of natural pastures with hay and concentrates is occasionally practised in seasons of drought by pastoralists. The use of concentrates as supplements to pasture is largely governed by economic considerations. The practice of using stock licks to supplement deficiences in the pasture is, however, more general. The value of a mineral mixture depends on the extent to which it supplies ascertained deficiences in the pasture, and work is urgently required to determine precisely what these deficiencies are in the various climatic and soil regions of Australia.

(*d*) *Conservation of surplus herbage.*—A vast amount of surplus herbage—beyond the immediate capacity of stock to consume it—is normally produced on pastures during the early summer. The stock-carrying capacity of the country could undoubtedly be greatly and permanently increased if portion of this surplus could be economically conserved for periods of scarcity. The conservation of such surplus growth from the pasture is practised to a limited extent on artificially seeded grasslands but rarely in the case of natural or indigenous pastures.

Economic considerations have hitherto prevented the conservation of surplus growth on indigenous pasture lands. These economic factors mainly relate to the cost of the process, the bulky character of the material, the deterioration which occurs when stored for long periods, and the cost of transporting material of low food value in proportion to its bulk. The progress of recent research work at Cambridge, which has demonstrated the value of young as compared with mature grass and the possibility of economically converting young grass of high protein and mineral content into compact edible cake, may be of significance to Australia.

The progress from extensive to intensive methods of production of animal products has begun, but the rate of intensification can be greatly accelerated by scientific research, by the application of existing knowledge to present practice, by the extension of demonstration and propaganda work.

4. Scientific Problems underlying Grassland Development.

The scientific problems underlying grassland development in Australia fall under three divisions:—

(1) Ecology.
(2) Agrostology.
(3) Genetics.

These have not been placed in order of importance, but in order of rational procedure.

1. Ecological Problems.

The first step in the scientific study, and therefore of the most economic and productive treatment of grassland, is the thorough examination of the natural composition, behaviour, and the succession of vegetation on grassland. The typical pasture sward is of a highly complex nature,

whether naturally or artificially established. Its composition and value from a grazing point of view vary considerably according to factors which, until recently, were regarded as uncontrollable. The extremely wide variation in types, the plasticity of susceptibility of grassland to slight changes of environment, the effect of the growth of one plant upon another, and the phenomenon of succession render grassland a particularly complex field of study.

The classification of the main types of pasture land according to the dominant constituents of the pasture, and the extent to which pasturage is apt to change its composition, and therefore its feeding value, under the influence of grazing, top dressing, burning, cultivation, &c., is of economic importance. The effect of grazing animals on any flora is more or less harmul, but the effect of this biotic factor, accentuated by periodic droughts which affect Australia, has been unusually severe, especially in the arid and semi-arid areas. Degenerative changes in the vegetation and the elimination of some of the more palatable species have resulted. Indeed, it is more than probable that some of the more valuable species have disappeared completely, and have been lost for ever to the pastoralist, as a result of the lack of knowledge of the ecological factors influencing indigenous grassland and the application of unscientific methods of grazing.

For some years past Professor Osborn of Sydney has been engaged upon a study of the effects of grazing on the indigenous pastures at Koonamore (8 inch rainfall), and on the regeneration of the indigenous flora in typically arid country. Increased facilities for the intensification of this work at Koonamore have recently been provided by the Council for Scientific and Industrial Research. The result of this ecological work will have an important bearing on the effects of overstocking in arid areas, and on the growth of fodder plants under low rainfall conditions. Similar work might be done in the summer rainfall region of Northern Queensland, and in the winter rainfall regions in association with some station on which animal health or animal nutrition problems are being investigated by the Council of Scientific and Industrial Research.

Ecological work on pastures is of practical significance where large tracts of semi-arid country are affected, and where the pastures will be rarely ploughed.

2. Agrostological Problems.

(1) *Plant Introduction.*

The introduction of new and promising economic plants is likely to lead to results of great economic significance to Australia. Plant introduction has formed a striking and successful feature of the work of the United States Department of Agriculture. The office of Foreign Seed and Plant Introduction secures from all parts of the world promising economic plants, propagates them, tests them in a preliminary way, and distributes them to Experiment Station workers and plant breeders throughout America.

Over 75,000 varieties of plants have been introduced by the United States Department since its inception, and a number of these plant immigrants has resulted in the establishment of industries of great magnitude. Among the strikingly successful introductions have been

the Durum wheats, Swedish barleys, Russian oats, cold and drought-resistant lucernes, grain sorghums, and Sudan, Rhodes, Kikuyu, Bahia, Dallas, Bermuda and Tracy grasses, and many Asiatic legumes and clovers.

The office conducts an exchange with foreign Agricultural Departments and Experiment Stations, the primary object being to transfer useful new plants from one country to another. Its explorers visit regions where particularly valuable economic plants are known to exist, and not only secure viable material, but detailed information regarding the cultural requirements of the plants, so that the plant immigrants can be readily established in their new habitat. There are great possibilities in the search for new plants, especially for pasture and forage plants that are cultivated little, if at all, in their native countries. This is most strikingly exhibited in grasses, many of which have been introduced accidentally.

There are undoubtedly in Africa, the Mediterranean regions, and in the drier regions of Asia Minor, many drought-resistant species which, if introduced into Australia, would add greatly to the carrying capacity of our semi-arid areas.

Among the many important species which have been introduced into Australia, apart from the valuable European pasture plants, are *Paspalum dilatatum, Phalaris bulbosa,* Kikuyu grass (*Pennisetum clandestinum*), Wimmera rye grass (*Lolium subulatum*), subterranean clover (*Trifolium subterraneum*), Sudan grass (*Andropogon sorghum*), Para grass (*Panicum barbinode*), &c. These introductions have led to greatly increased output of animal products from the pastures of Australia.

Plant introduction in Europe has been confined mainly to the search for strains of gramineous and leguminous plants of value for humid temperate areas. In the United States the main objective has been to search for annual fodder plants of value to the corn belt, hardy cereals for the winter wheat region, and fruits and grasses for the tropical southern areas.

Australia's present needs are mainly for drought-resistant perennial grasses and fodder plants for the semi-arid areas, and suitable grasses and legumes for temporary pasture and rotation purposes in the wheat belt, and improved strains of European herbage plants for the south-eastern grassland region.

An organized Plant Introduction Service is urgently needed in Australia, and the Council for Scientific and Industrial Research, acting in close collaboration and co-operation with the States, would appear to be the organization best adapted to undertake this work on a national basis. The introduction of plant immigrants concerns the whole Commonwealth, and success in plant introduction is dependent on the establishment of plants in natural climatic regions, rather than within the political boundaries of a State. The Council can establish effective liaisons with the Royal Botanic Gardens, Kew, Washington, Ottawa, Pretoria, India, &c., and will be able to take advantage of the explorations which have been conducted by kindred organizations without unnecessary duplication of effort, and at comparatively small expense. There are always risks involved in the introduction of new plants, because of the possibility of introducing new insect and fungus pests. These risks would be reduced to a minimum under the Council for

Scientific and Industrial Research with its Plant Pathological and Entomological Sections working in co-operation with the Commonwealth Department of Health.*

Finally, with the establishment of pathological, physiological, and genetical sections under the Division of Economic Botany of the Council for Scientific and Industrial Research, ample opportunity would be given for close collaboration in the study of any given plant introduction so that promising types of plants would be available for field testing by State Departments of Agriculture in the shortest possible time.

Advantage should be taken of the fruits of exploration by other countries, especially the Plant Introduction Service of Washington, concentrating first on promising types of pastural and fodder plants. The British Empire has not shown the same keenness for organized plant exploration and plant introduction work as the United States, which has combed the world for promising strains of plants of special economic value for its own special requirements. With such institutions as the Royal Botanic Gardens at Kew, and the Plant Breeding Station at Aberystwyth it should be possible to organize a service to discover species of grasses and herbage plants of economic value to the grass lands of the Empire, and even to the grasslands of Britain.

The acceptance by the Council for Scientific and Industrial Research of the obligation to establish an organized Plant Introduction Service need not in any way interfere with the right of State Departments of Agriculture to undertake plant introduction work. Many valuable plants have been introduced by the New South Wales Department of Agriculture, and there is no reason why a State Department should not continue to introduce plants which may be suitable to its special climatic conditions, or to its agricultural industries.

The aims of the Plant Introduction Section would be—

(*a*) the systematic exchange of experimental seeds and plants with corresponding organizations in foreign countries;

(*b*) the scientific study of the material from the nutritional, genetical and physiological aspects;

(*c*) the testing of selected material in suitable climatic regions in co-operation with the State institutions and plant experimenters.

(2) *Grassland Survey.*

In regard to agrostological problems other than those involved in new introductions, there is a wide field of work, part of which might be covered by State institutions.

The scientific investigation of the characters, habits, and qualities of the indigenous and exotic herbage and pasture plants, which constitute the natural and artificially seeded pastures of Australia, is an important and fundamental part of the work of grassland development. It is very important to determine the persistence, palatability, drought-resistant capacity, seed setting, and other characters of—

(*a*) the more important indigenous plants;

(*b*) introduced plants of economic value for the grassland regions.

* Which is responsible for quarantine measures.

The fullest investigation is needed, not only of the valuable native species, but of species which have proved of value in other countries with similar climatic and soil conditions.

The work should be continuously directed to problems relating to the improvement of natural and artificial pastures. Portion of the work in this field is of a fundamental nature, and portion of it consists of the application of existing knowledge.

The first step is to classify the grasslands of each climatic and soil region—to determine the more important species of plants contributing to the pasture—by what means the species are perpetuated in the pasture, and their relationship in the sward under varying conditions of rainfall, grazing, management, top-dressing, &c. Such a classification and survey may, in the first instance, be of a reconnaissance nature, and could be intensified later as and when circumstances justified.

Such a survey, correlated with existing information on pasture management, would indicate—

(*a*) The dominant and sub-dominant species of pasture plants in each climatic and soil region—the establishment of unit areas based on similarity of composition.

(*b*) The probable extent of the area that could profitably be converted to artificially seeded grassland.

(*c*) The possibility of successfully establishing new types of pasture plants in each unit type of grassland revealed by the survey.

Such a survey might be carried out by State officers of the Departments of Agriculture, working on a uniform plan in co-operation with the Division of Economic Botany.

(3) *Improvement of Natural Pasture.*

The most fruitful avenues of attack are:—

(*a*) Top-dressing with artificial fertilizers.

(*b*) The feeding of licks to supplement the deficiences of the pasture.

(*c*) The harrowing, burning, and re-seeding of the indigenous pasture.

(*a*) *Top-dressing with artificial fertilizers.*—Extensive work has been conducted by the New South Wales, Victorian, and South Australian Departments of Agriculture during the past decade on the top-dressing of indigenous, seeded, and irrigated pastures.

These investigations have led to the conclusion that the productivity of the pasture can be greatly increased by the application of soluble phosphates, that the health and vigor of the grazing animals have been greatly improved, and that the response to top-dressing with phosphates is largely determined by the amount of rainfall and by the soil type.

The further extension of top-dressing with phosphates is now largely a matter of demonstration and propaganda, and of economic considerations. The general value of top-dressing has been well established in the moister areas of the southern grassland region. The effect of top-dressing on the yield and botanical composition of the pasture, and the

stock-carrying capacity have been ascertained, but the effect of top-dressing on the yield and quality of the wool still remains to be investigated.

In the more favoured rainfall regions, the possibilities of supplementary dressings of nitrogenous fertilizers need thorough investigation, especially in view of the recent work in Europe on the intensive production of grassland with nitrogen. Very little information on the importance of nitrogen for grassland farming is available for Australian conditions.

(*b*) *Feeding of licks to supplement deficient pastures.*—The supplementing of the pastures with mineral licks has been fairly common in certain districts of Australia particularly in Queensland, New South Wales, and Western Victoria, but the practice of using licks needs to be put on a scientific basis by ascertaining the major mineral deficiencies in each grassland region, and adjusting the composition of the lick to ascertained deficiencies of the pasture. These deficiencies will vary in different grassland areas, in different seasons, and at varying periods of the year. Exact information on the character of these deficiencies is required, and until these deficiencies have been ascertained, feeding on licks will remain on an empirical basis. Two problems are involved here:—

(i) The determination of the mineral content of the herbage and the effect of the soil type, pasture composition, stage of growth, and soil water supply on the composition of the pasture growth.

(ii) The conduct of feeding experiments to determine the most profitable form in which the deficient nutrients in the pasture may be supplied to stock.

(*c*) *The harrowing, burning, and re-seeding of indigenous pasture.*—The possibility of improving indigenous pastures by re-seeding, combined with burning, harrowing or cultivation, needs further investigation.

(*d*) *Seeded pastures.*—The State Departments of Agriculture, especially the New South Wales Department, have done much valuable work in demonstrating how production in the better rainfall areas may be increased by the replacement of indigenous vegetation with seeded exotic pasture plants. Apart from the extensive use of the common European pasture species, e.g., perennial rye grass, cocksfoot, white and red clover, fescues, &c., large areas have been sown with introduced pasture plants. Prominent among these are paspalum, lucerne, *Phalaris bulbosa*, Rhodes grass, Wimmera rye grass, subterranean clover, Kikuyu grass, and Sudan grass. Over 4,000,000 million acres have been sown in seeded pastures in Australia. This area is significant in comparison with the area of Australia, and the area under seeded pasture could undoubtedly be greatly increased with advantage to the pastoral and dairy industries. The grassland survey referred to above would indicate the more promising regions for development.

An intensive study of the botanical and economic characters of introduced pasture plants needs to be made. Such investigations would include the conditions affecting seed germination, the inter-actions of the

plants to soil and climate, the effect of nutritional factors on growth, yield, palatability, and seeding capacity, the persistence of the types under varying environmental and grazing conditions. Such work should be accompanied by agronomic work on the time of sowing, rate of seeding, cultural and fertilizer requirements of exotic plants and methods of establishment of the pastures. Selection of improved strains with especial reference to environmental conditions would form a natural supplement to this work.

The Departments of Agriculture are already engaged in some phases of this work, and it is highly desirable that they should continue and develop it. These efforts should be supplemented by the Division of Economic Botany which would concentrate on the more fundamental aspects.

3. Genetics and Herbage Breeding.

The ecological and agrostological work above must be backed by plant breeding work.

In regard to herbage breeding it would be undesirable for many reasons to duplicate the very important and valuable breeding work in progress at the Welsh Plant Breeding Station, Aberystwyth, on cocksfoot, rye grass, red and white clover. To duplicate such work would not only be very costly, but would require a scientific staff with a specialized knowledge of European grasses. For the immediate future, Imperial interests might be better served by providing facilities in the uniform rainfall area on the mainland and in Tasmania for the thorough testing of strains developed at Aberystwyth to determine their suitability for Australian conditions. If such tests definitely demonstrate that the strains developed at Aberystwyth are unsuited to Australian conditions, then it may be necessary to consider the best method of producing by local effort the improved European herbage plants required for Australian conditions. Before any such step is contemplated, the thorough testing of Aberystwyth material should be made.

On the other hand it is highly desirable that work should be undertaken on those species of herbage plants which are of great value to Australia, the drier parts of New Zealand, and South Africa, work which cannot be conducted at Aberystwyth or indeed in any other part of the Empire so well as it can be done in Australia, since the main problem is that of drought-resistance. Investigational work on indigenous pasture plants, both from the agrostological and genetic aspects, has been in progress for some time at the Waite Institute. A factor of great importance in the drier areas of Australia, New Zealand, and South Africa is the liability of vegetation to crucial periods created by prolonged dry weather, high temperature, low humidity, intense light, and drying winds. In temperate Australia, these periods are normally manifest from November to April. A study of the vegetation induced under such conditions gives a reliable indication of the types of pasture plant most likely to succeed. Two distinct types of pasture plants are met with under these conditions: (1) perennial types, with well-developed underground root stocks, e.g., *Danthonia, Themeda, Stipa;* (2) annual types, with early maturing and early seeding habits, which seed on or before the approach of dry weather, e.g., *Festuca, Bromus, Hordeum, Erodium,* and the annual clovers (cluster, woolly, knotted, and subterranean clover, and burr medick).

The tiding over of crucial periods common to Southern Australia and the drier parts of New Zealand is due to what may be termed their drought-resistance; this, in the case of perennials, may be merely the capacity to live through a period of relatively dry weather without adding materially to the herbage until the ensuing break of the season, or to the ability, e.g., in the case of perennial saltbushes (*Atriplex* and *Kochia*), to make use of ecologically ineffective rainfall (e.g., 15 inches or less) by means of leaf absorption; and at the same time they have been shown to possess a low transpiration rate, relatively independent of environmental conditions. In other cases, again, the root, stock, and base of the stem is covered with a protective sheath (e.g., *Themeda*). Finally, the early seeding habits of certain annual grass and small clovers ensure their appearance in the pastures in the following autumn with the first break in the weather.

There are many species of grass and clovers which would amply repay intensive investigations, but of outstanding importance is the large and extraordinarily valuable group of plants included in the genus *Danthonia* (wallaby grass and its allies), which is common to Australia, New Zealand, and South Africa, and in which species there has already developed a considerable seed trade.

This genus forms the bulk of the perennial grass throughout the natural pastures in the sheep and wheat belt of the Commonwealth, and investigations at the Waite Institute have shown that numerous herbage forms are to be met with in every species of *Danthonia*. The *Danthonias* form very attractive material for investigation because of their recognized value as sheep and wool-producing grasses, their great drought resistant character, the extraordinary range of variation of types within each species, and the fact that they are perennial, deep rooting pasture plants of the highest nutritive value for stock. Moreover, they are found not only in Australia, but in New Zealand and South Africa, and have been cultivated in California. Apart from these grasses, the small annual clovers are of great potential value, and may prove to be of the greatest importance to the development of semi-arid lands in the Empire.

There are no indigenous members of the *Trifolium* family in Australia, but the introduced annual clovers have done extraordinarily well and subterranean, cluster, hop, woolly, and burr clover (*Medicago denticulata*) have been of exceptional value in the dried areas for pasturage in association with indigenous grasses. The great value as pasturage of subterranean clover throughout Southern Australia is an indication of the possibilities which await the exploitation of the annual clovers in the drier portions of the Southern Hemisphere.

Material should be collected from all these countries where the various genera thrive, and should be critically studied at some central institution located in the winter rainfall region, where adequate staff, equipment, laboratories, and testing grounds are available.

Report on the Establishment of a Commonwealth Museum at Canberra.

The article that follows comprises the report of a Committee that was recently appointed to advise the Federal Government on the possible establishment of a National Museum at Canberra. The report was completed in October, 1928.—Ed.

1. At the request of the Commonwealth Government conveyed by the Rt. Hon. the Vice-President of the Executive Council, the Committee consisting of Dr. C. Anderson, Director of the Australian Museum, Sydney, Mr. J. A. Kershaw, Curator of the National Museum, Melbourne, and Dr. A. C. D. Rivett, Chief Executive Officer of the Council for Scientific and Industrial Research, was formally constituted at the end of September, and met at the offices of the Council on Thursday and Friday, October 11th and 12th. The various letters and memoranda which had led to the appointment of the Committee were read. These indicated that no specific terms of reference were given to the Committee, but that it was desired that it should look broadly at the whole question of the desirability or otherwise of establishing at Canberra, either in the present or in the future, a Museum of Natural History. In the event of its being of the opinion that such a Museum was desirable, it was understood that the Committee would indicate the lines upon which development should proceed.

2. The Committee desires first of all to place on record its appreciation of the attitude of the Commonwealth Government as reflected in its decision to appoint a Committee to examine this general question. The desirability of careful long-sighted planning of a national institution of the kind has repeatedly been made apparent in the past. Many existing Museums are suffering seriously from the fact that their development has been a haphazard, rather than a systematically planned, progress. From every point of view, it is desirable that from the very beginning of any Australian national scheme for Canberra, full advantage should be taken of existing experience and knowledge in order that the most effective service may be devised both for the present and the future.

3. The initial question of the desirability of developing a Commonwealth Museum has been fully discussed. The Committee is of the opinion that at the present time, the need for it is probably not great. There are admirable Museums in the States, capable in most, though not all, respects of meeting existing needs both of students and of the general public. It is felt, however, that taking a long-range view, there is every possibility that Canberra will become a great centre of intellectual work in all the sciences, and that in course of time the need for a Museum to cover all branches of natural history will be imperative. Even though the need to-day may be slight, it is most desirable that systematic plans for the future should be made at this stage in order to ensure effective and rapid development when the right time comes for extended action.

4. In the sequel the proposed museum will be referred to as the Commonwealth Museum. The Committee considers that this is the most satisfactory name that can be given to it. It expresses just what the Museum is designed to be, and avoids possibility of confusion with existing institutions already described as "National" or "Australian".

5. In view, however, of the existing Museums in Australia and the present stage of development of the Commonwealth as a whole, and of Canberra as the location of the Commonwealth Museum, the Committee maintains that any project for the immediate establishment of a huge and complete Museum would be ill-advised. In one particular direction, as will be indicated presently, it is felt that immediate action may well be taken, but otherwise the development of the main project may best be spread over a considerable period of time, provided that steps are taken as soon as possible to initiate certain activities that are essential if later developments are to proceed with maximum efficiency.

6. The housing of a museum being an outstanding matter for consideration, the Committee first directed its attention to the possibilities at Canberra, having before it ground plans showing the areas already set aside for the buildings of the Council for Scientific and Industrial Research, the University, the Institute of Anatomy, and other proposed institutions. It has come to the conclusion that the Commonwealth Museum should most certainly be erected in the same neighbourhood, and that, on the evidence before it, a desirable area would be the block of about 10 acres at the foot of Black Mountain, overlooking Sullivan's Creek and the University site and lying south-west of the C.S.I.R. Reserve. The advantages of developing all major scientific activities in close geographical association with one another are very great. They will be particularly apparent in such cases as a Natural History Museum on the one hand, and such botanical and entomological research laboratories as are about to be established at Canberra, on the other.

As to the type of building at which to aim, it is the opinion of the Committee that in view of the way in which the national project is likely to develop it would be very unwise to aim at one single building to house everything. It would be better to aim at a group of detached, but fairly closely-spaced buildings, each erected in a way to permit of enlargement in a systematic manner as the need may arise. The general lay-out and the style of architecture could be determined from the beginning, leaving all matters of detail to be settled as future experience may dictate.

7. The Committee discussed at length the position of the proposed Institute of Anatomy in relation to a National Museum. In so far as this Institute is to be devoted to research work in medicine and surgery, it might be inadvisable to associate it directly with the Museum. But looked at as a museum of comparative anatomy, comprising all types of Australian zoological specimens, such a place might very well be constituted as the first unit in the Commonwealth Museum, self-contained and with its own Keeper or Curator, but destined in course of time to take its place in the group constituting the whole Museum.

In that case it should be located in the area selected for the units of the future. The Committee, however, is not in possession of full information as to existing commitments regarding the Institute of Anatomy, and beyond expressing the general view that it would be well for this Institute to come into a general scheme rather than to remain wholly independent and separated from it, it prefers not to pursue the matter further for the present.

8. The one direction mentioned in section 5, in which it has been decided to recommend immediate action, is the establishment of a

Section of Anthropology to constitute the second section (assuming the Institute of Anatomy to be the first) of the Museum. Such a section should be constituted on a much broader basis than the ethnological divisions of the State Museums. It could, in fact, fill a need in Australia which is not at the present time being met elsewhere.

The Committee understands that at the present time the Commonwealth possesses a considerable amount of material for such a sectional Museum, and, even more important, it realizes that there is in the new School of Anthropology in the University of Sydney, for which the Commonwealth is largely responsible, an admirable agency for the collection of material both on the mainland and in the adjacent islands, Such collecting work must be undertaken very quickly, or the opportunities for it to be carried out thoroughly and at reasonable financial cost will be altogether lost.

9. The available material includes a considerable Papuan collection at present housed in the Australian Museum, Sydney, and in the National Museum, Melbourne; the McGregor Collection, at present in Brisbane; the collection bequeathed by Mr. Milne, formerly Railways Commissioner in New South Wales; and the collection of native stone instruments presented some time ago by Dr. Horne, of Victoria. There is really an obligation to-day upon the Commonwealth to find a home for those collections, to which additions might reasonably be expected to be made very rapidly. The chief avenue of growth would be the research school in Sydney, under Professor Radcliffe Brown, mentioned in the last section.

The erection at as early a date as possible of a building to be complete in itself, architecturally attractive and capable of systematic expansion as time goes on, is recommended as the next proper step in the development of the Commonwealth Museum.

10. As an immediate first step in organization, a well-trained man should be sought to take charge of the section. It would probably be advisable to send him abroad for a short time to study corresponding institutions elsewhere. He would then be able to give up-to-date advice as to the most desirable organization for the section, including advice on the type of building likely to prove most satisfactory. It would be the duty of this officer to link up very closely with the School of Anthropology in Sydney, and to take immediate possession of the materials named above, and possibly also the collections known to be available at Rabaul, if indeed they have not already passed, through neglect, beyond hope of salvage.

11. With regard to other sections such as those broadly included under the heading zoological, botanical, and geological, the Committee is of the opinion that no immediate action in the way of erecting buildings is called for. There is not a clamant need for such sections at Canberra at present; but a need may be expected to grow in course of time.

The Committee therefore recommends that steps be taken at once to ensure systematic collection, under trained guidance, of material likely to be required later, particularly material which is likely to become extinct or rare as the years pass. A small staff, not necessarily of full-time officers, might very well be appointed for this work. It would form what might aptly enough be termed a

"Scouting Division." It would establish close touch with the State Museums, which might often be able to supply duplicate specimens for the future use of the Commonwealth Museum.

It would be the duty of such officers also to examine any collections which might be offered to the Commonwealth either as gifts or for sale, and to ensure that these be considered very thoroughly and reported upon from the point of view of their scientific worth and suitability for a national museum. They might also even carry out a survey of existing private collections, the owners of which might be induced to part with them to the Commonwealth.

12. Pending growth of the collections of the Anthropology Section, portion of the building erected for it could well be used for the temporary housing of other collections until such time as special buildings for them seem to be warranted.

13. In order that there should be adequate control of the whole project from the beginning, the Committee holds that it is desirable to constitute at once a body, for which it tentatively suggests the title of Board of Trustees, the members of which would act in an honorary capacity, and to which the Commonwealth should give power to secure and hold on its behalf whatever buildings, collections, and other property may in course of time come to constitute the Museum.

Just what the relations of this body to the Commonwealth Government should be, the Committee is not prepared definitely to suggest at this stage. It is of the opinion, however, that it would be inadvisable to place the Museum directly under one of the usual Departments of State, and suggests tentatively that the Board of Trustees be made directly responsible to the Prime Minister, who might see fit to delegate his authority to the Vice-President of the Executive Council. A good deal might be gained by associating such activities as a Commonwealth Museum, the Council for Scientific and Industrial Research, and no doubt others, under the same Minister of State.

14. The constitution of the Board, the members of which might be given a tenure of, say, five years, is a matter requiring considerable thought. Without wishing its recommendations to be regarded as final, the Committee is of the opinion that the number of members should be kept as small as possible; but it seems that at least nine will be necessary to meet obvious requirements. It is tentatively suggested that these be—

(*a*) Two representatives of the State Museums, to maintain touch with these institutions and the Commonwealth Museum and to advise on all questions of co-operation, avoidance of overlapping, &c.;

(*b*) one member chosen for his special knowledge of the needs of the Section of Comparative Anatomy (if this were included in the general project);

(*c*) one similarly chosen for his knowledge of the Section of Anthropology;

(*d*) two chosen for similar reasons from the stand-points of Zoology and Geology, respectively; and

(*e*) one to represent the Council for Scientific and Industrial Research and to assist in securing and maintaining the closest possible contact between it and the Museum.

This would mean seven members, to whom it might be very desirable to add two others representative of more general public interests. A total of nine is perhaps rather large, but it is difficult to see how it can well be reduced.

To ensure satisfactory working there should be associated with the Board a full-time officer, with adequate scientific training, competent to supervise, under the direction of the Board, the steady development of the whole project.

15. There remains the question of finance, and the Committee takes the view that, until the general scheme is approved, it is idle to go into any great detail.

There will be the cost of the Section of Comparative Anatomy, to which the Commonwealth appears already to be committed. As part of a Commonwealth Museum it is just possible that this might be conducted at less cost than as an independent institution. The Section of Anthropology will require a building which will cost several thousands of pounds. A director and an adequate supporting staff will be necessary. For the rest, there would be the "Scouting Division," which would need to be very highly trained though not numerous in personnel.

16. These general proposals are submitted for the consideration of the Right Hon. the Vice-President of the Executive Council. The Committee expresses its willingness to go more fully into the matter if it is desired to do so. It is apparent, however, that if the proposal to form a Board of Trustees be acceptable and be adopted, it will be the appropriate body to work out details of the scheme and look thoroughly into the whole matter of future development.

Possibly an Act of Parliament may be required to constitute a Board of the type suggested. The drafting of the Bill will require close attention from people with considerable experience in the running of national museums.

17. It might perhaps be well to refer these proposals to the heads of the various State Museums, inviting their comments. The views of the Australian National Research Council, the several Royal Societies, and the Linnean and Royal Zoological Societies of New South Wales might also be sought, because the wider the interest that can be aroused in a scheme for creating in the years to come a thoroughly worthy National Museum for the Commonwealth the better from every point of view.

Bunchy Top in Bananas.

By Professor E. J. Goddard, University of Queensland.

The results of the co-operative work carried out by the Department of Agriculture of New South Wales, the Department of Agriculture and Stock of Queensland, and the forerunner of the Council (the Institute of Science and Industry) have been reported elsewhere.*

Since that report was issued, Professor Goddard has carried out further work, the results of which are included in the article that follows.—Ed.

1. Introduction.

An attempt is made in this brief article to set out the present position with respect to our knowledge of the disease known as bunchy top in bananas, and the control of that disease.

Bunchy top, curly top or cabbage top, is a disease known to affect all available species of banana plants, as well as Manilla hemp, and in the present state of our knowledge, we may regard it as a malady confined to species of the genus *Musa*. The disease, which has been known in Australia for about seventeen years, is recorded also from Egypt, Ceylon, the Philippines, Bonin Islands, Fiji, and Ellice Islands. So far, there has been no record of the disease from other banana-producing areas such as those of Central and South America, the Canary Islands, Natal, Zululand, and parts of Africa other than Egypt. In Ceylon, the Philippines, Fiji, and Australia, bunchy top has wrought great damage to the banana industry, and in the first-mentioned two places is seriously damaging the Manilla hemp industry as well.

The disease is well named, the outstanding characteristic of a thoroughly infested plant being the rosetting of the leaves at the top of the plant, this resulting from a shortening of the leaf stalk and a narrowing of the blade, the latter also showing a wrinkled surface and becoming very brittle as well as dark green in colour. A plant in the early stages of the disease may, in respect of the above-mentioned characters, appear quite normal, but it will soon indicate the presence of the disease by the erect and short-stalked nature of the later leaves. Ultimately, such a plant will take on the extreme bunchy top habit. While extreme winter or drought conditions may bring about what is termed "choke" (so-called on account of the inability of the bunch of fruit, which is growing up from below through the centre of the false stem, to emerge), yet it is impossible to confuse this condition, which closely recalls that of bunchy top, with the latter disease, inasmuch as the infallible sign of bunchy top is the presence of dark green broken streaks running parallel with the secondary veins in the blade of the leaf. These streaks are much more prominent than the veins, and are best described as resembling the signs of the Morse code. Frequently, similar streaks will be found along the back of the leaf stalk, particularly in its lower part. The presence of these streaks enables the grower to identify the disease with certainty, even long before the other outstanding

* Commonwealth Council for Scientific and Industrial Research, Bulletin 30, 1927.

symptoms have appeared. In fact, there is no plant disease which can be more readily identified, even in the early stages of the disease, as for example, in the case of a plant which was originally healthy but has contracted the disease sufficiently recently as to show the only symptoms in the last or youngest leaf. One important fact in connexion with diseased plants is that they can live on for years, and, as set out later, may serve to spread the disease to healthy plants. Plants which become affected with the disease while still young, take on a dwarf habit, and in the case of plants which, so to speak, are born with the disease, the individuals retain a miniature stature. In general the root system of diseased plants becomes degraded, and the cortex of the underground part or corm tends to decompose. In respect of the internal symptoms, the outstanding feature is the replacement of woody tissue associated normally with the veins, by cells containing abundant chlorophyll, and, more important still, the failure of the phloem tissue to differentiate into sieve tubes those parts of the veins which, in the normal plant, serve to convey the organic products elaborated in the leaves to other parts of the plant. Except in the case of plants which are about to throw a bunch, or have already thrown a bunch, before developing bunchy top, diseased plants fail to yield fruit.

2. The Bunchy Top Investigation.

Since 1885, when the disease was first recorded from Fiji, attempts have been made to determine its cause and nature, and gradually as it made its appearance in other lands, numerous investigations were initiated. The position in Australia became so serious that, in the absence of any solution of the problem coming from other countries, a Bunchy Top Investigation was brought into being in 1924 through the co-operation of the Governments of the Commonwealth, New South Wales, and Queensland, with the object of carrying out researches into the cause and nature of the disease, and determining the means of combating the same. The investigation which undertook its responsibilities in May, 1924, was able to determine that bunchy top was a virus disease, that no available species of banana was immune to the disease, that it affected Manilla hemp, that it appeared to be restricted to species of the genus *Musa,* that it was of a systematic nature, that the disease could not be eradicated from an affected plant, that all plants descended from an infected plant were born with bunchy top, and that the disease could be transmitted to healthy plants by means of an aphid (*Pentalonia nigronervosa*) after it had fed on a diseased plant. These facts have been set out in Bulletin No. 30, published by the Council for Scientific and Industrial Research, and prepared in excellent fashion by Mr. C. J. P. Magee, B.Sc.Agr., who was Assistant Plant Pathologist to the Bunchy Top Investigation. The above-mentioned facts find a place in this brief article in view of their bearing on further developments of our knowledge with respect to the disease.

3. Theories as to the Cause of the Disease.

Prior to the appointment of the Bunchy Top Investigation, many theories had been elaborated, and of these the most important were those which suggested a fungus, bacterium, eel-worm, or various insects

as possible causal agents, or postulated unsuitable conditions, degeneration of the plant stock, &c., as responsible for the disease. The Bunchy Top Investigation was unable to detect any fungus or bacterium which could be regarded in any way as being associated in the capacity of causal agent with the disease. The condition of the roots which had previously given encouragement to investigations aiming at the discovery of such a type of causal agent, was later found to be secondary, that is to say, it results from the presence of the disease in the plant. Experiments and observations gave little support to the eel-worm theory, and frequently it was found that healthy plants showed an abundance of eel-worm nodules on the root, whereas sometimes plants suffering with bunchy top showed no trace of such nodules. Eel-worms abound in the banana lands of Queensland in areas far removed from localities where bunchy top is prevalent. The occurrence of the disease in such ideal banana lands as the Philippines and Fiji did not support the idea that climatic factors were concerned, and field observations in the affected areas in Queensland and New South Wales gave less support still to this idea, as well as to the suggestion that the disease was due to a degeneration of the plant stock. Frequently, it was observed that suckers shifted from a healthy plantation to another locality eventually developed bunchy top, whereas suckers of the same origin planted out in a third locality stood up against the disease to a greater or less extent.

On the top of all this negative evidence, the discovery was made that aphides transferred from diseased to healthy plants grown under nets or in an insect-proof glass house, never failed to transmit the disease, and in no case were control plants, that is, plants of the same origin as the healthy plants and grown under similar protected conditions, found to develop the disease. Further, in a series of control experiments in which six sets of soil were utilized (a number of tanks with steam-sterilized soil from North Queensland, a number of tanks with non-sterilized soil from North Queensland, a number of tanks with steam-sterilized soil from Brisbane, a number of tanks with non-sterilized soil from Brisbane, a number of tanks with steam-sterilized soil from the Tweed, a number of tanks with non-sterilized soil from the Tweed—the two latter sets of tanks being taken from a bunchy top plantation—it was found that whether the soil were steam-sterilized or not, healthy plants to which infected aphides were transferred invariably developed the disease, and that control plants grown in corresponding tanks and protected against aphides did not develop the disease. Again, it was proved that aphides taken from healthy plants growing in areas where the disease did not exist failed to transmit the disease to the healthy plants. More important still, it was found that the symptoms of bunchy top in successful transmission experiments appeared about 26 days after the actual transfer of the aphides, thus indicating something corresponding to an incubation period.

One interesting experiment consisted in growing together in one tank bunchy top and healthy plants, all plants being thoroughly free from aphides before planting. The tank in which the experiment was conducted was protected against insects. Under these conditions the healthy plants grew and failed to develop the disease, and before the termination of the experiment it was found that the roots of healthy and unhealthy plants were most intimately associated, yet the disease

was not transmitted. In a similar experiment repeated since, over a period of nine months, the same result was attained, and ultimately, prior to the removal of the plants, healthy aphides were placed within the net; in less than a month the healthy plants had all developed bunchy top, the healthy aphides in some cases apparently having fed on the diseased plants and transmitted the disease to the healthy plants.

On this evidence the Bunchy Top Investigation reported bunchy top as a virus disease which could be transmitted by the banana aphis, *Pentalonia nigronervosa,* from diseased to healthy plants. Since the publication of the Investigation's report, the experiments have been repeated many times in Queensland and in the Philippines, with the result that the findings of the Investigation are to-day unassailable. The history of the disease in Australia is markedly consistent with the ideas propounded by the Investigation. It has been found possible to locate the site of the first occurrence of bunchy top in Australia, and to learn that from that plantation to which diseased plants were brought from Fiji, where bunchy top has occurred since 1885, the disease was distributed directly by the shifting of suckers to other plantations. Undoubtedly this direct means of spreading the disease is assisted by the aphis. The early history of Currumbin, in South-Eastern Queensland, indicates that suckers were obtained from the Tweed area in New South Wales, and that bunchy top made its appearance immediately—a happening that can now be readily understood, in view of the fact that the disease was already widely spread in the Tweed area. These failures at Currumbin led growers in that area to obtain plants from Northern Queensland, and it was found that these plants stood up against the disease for a longer period, but eventually and gradually they gave way. All this is understandable as the work of aphides travelling from affected plantations which were near at hand. During the past three years, and more particularly within the past year, there has been a series of reports of spasmodic occurrences of bunchy top along the North Coast of Queensland; in some cases at spots practically 50 miles from the nearest recorded bunchy top plantations. In every such case it has been found that the symptoms of the disease were to be made out only in the younger leaves, thus indicating that the affected plants were originally healthy, and that the disease must have been borne to them in some way. We are justified in concluding that aphides were responsible. Quite a number of examples of this type of occurrence of the disease could be quoted. Undoubtedly all this supports the findings of the Bunchy Top Investigation.

4. The Role of the Banana Aphis.

Within the past three years, a great deal of attention has been devoted to the life history of the aphid, and a study of its migration, inasmuch as a knowledge of such can render much assistance to the solution of the practical problem. The aphides occur commonly as masses or colonies, particularly in the heart or crown of the plant, where the nature of the tissues suggests ideal aphid-food, and protection from the weather is excellent. Such colonies consist throughout the greater part of the year of wingless female aphides. It is individuals of this type that were used in transmitting the disease from diseased to healthy plants. At certain times of the year winged

forms arise, and with their appearance migration begins. It is found, from observations under nets and in glass houses, that the winged forms tend to ascend rather than to fly actively. This has been noted so constantly that it suggests that aphides make use of the currents of the air in their migratory distribution. Inasmuch as individual winged forms have been observed to maintain themselves on the wing for over four hours, it may be concluded that with the aid of a breeze the aphides could be carried very considerable distances. In fact, this observation has a most important bearing on the immediate demands of the bunchy top problem, and the spread of the disease within the past year along the North Coast of Queensland lends great support to this contention. Another interesting fact which has been specially observed along the North Coast of Queensland, and which was also noted during the period when the Bunchy Top Investigation was at work, is that the disease will make its appearance at times in isolated plantations where the topography and thick scrub or forest suggest protection, specially when it is assured that the plantation is stocked with plants originally 100 per cent. healthy in so far as bunchy top is concerned. In some parts of the North Coast of Queensland, the only plantation in a district to become infected has been of such a type, and yet there are other plantations in the same district which are freely exposed. Investigations along the whole coastal area from the Tweed to the banana-producing areas of the North Coast of Queensland indicate strong down-draughts of varying position at different times of the year. There can be little doubt that the explanation of these peculiar distributions lies in the fact that the aphides depend on air currents for their wide distribution, and that down-draughts serve to bring about the infection of isolated plantations. It has been found that there are two associations of aphides, and that each association is double brooded. Winged forms are abundant during September, and when such forms settle on banana plants they give rise to colonies, the members of which go on reproducing wingless forms for a period of about five months. At intervals, winged forms arise from such colonies in very small numbers throughout the period of its existence, but the big and ultimate appearance of winged forms takes place at the end of January and the beginning of February. From the latter will arise the colonies destined again during the following September to provide a migratory host. The second association is responsible for winged forms during the latter part of November and the early part of December. They result in colonies which, while giving rise at intervals to a few winged forms, will provide the biggest winged migration of the year at the end of March and the beginning of April.

5. Suggestions for Control.

Careful analysis indicates that the times of rapid spread of bunchy top can be co-ordinated with the maximum winged migration of aphides during September, November-December, January-February, March-April. There are practically no winged forms during the month of June and July, and there is a marked paucity during the latter part of May and the early part of August. In any attempt to adopt protective measures, these periods would be of the greatest use. In this connexion, it may be stated that protection against bunchy top by the utilization of aphicides, &c., is hardly likely to be very successful. It is granted that where experiments have been

carried out, as by the use of kerosene emulsion and black leaf 40, some measure of result can be detected, but this procedure cannot be recommended as of primary importance. Yet the adoption of a scheme of spraying when one is removing a diseased plant during the time when the winged aphides are abundant, might be expected to yield good results. It is important to bear in mind that whereas spraying will do much good in a fight against aphides doing mechanical damage, as for example, in the case of aphides affecting young leaf-shoots, yet in the case of bunchy top less success would appear to be likely. It has been demonstrated that a single aphid from a bunchy top plant is capable of transmitting the disease to a healthy plant. The number of aphides which are on the wing during the peak periods of the year is so large, that it would appear much more important in the fight against disease that growers should know the symptoms thoroughly, should thoroughly inspect their plantations —which also means that they should recognize that no man can safely look after more than 5 acres whether it be from a cultural or any other point of view, should immediately destroy any bunchy top plant or plants after detecting the disease, and should assist himself and others by having the utmost regard for the regulations now in force in New South Wales and Queensland. These regulations insist on an inspection of any plantation from which suckers are to be moved, and aim at preventing planting-up in areas or plantations seriously affected with the disease.

The original recommendations of the Bunchy Top Investigation made special stress on the necessity for the immediate eradication and destruction of infected plants, the destruction of deserted plantations, and an embargo on the shifting of suckers from infected areas, as well as recommending other minor measures which might be regarded as accessory to these three major recommendations. The last of these three has been in force by the Governments of the two States concerned, and undoubtedly a great check to the spread of the disease has thus been exercised. Had this not been done, the whole of the banana-producing areas of Australia must have succumbed to bunchy top. The procedure in respect of the first two recommendations has been more difficult, yet a gradual cleaning-up has proceeded. The biggest problem, however, is that of the deserted plantations. Strangely enough most of the plantations that could be described as deserted three years ago, when the recommendations were made, have disappeared; but in the meantime other plantations are being deserted to the extent that the problem of the deserted plantations is greater to-day than ever—more notably in Queensland. This is largely due to the fact that growers in unaffected areas still fail to recognize that, whether bunchy top is present or not in an area, the creation of deserted plantations is nothing more than a request for trouble. This calls for special mention owing to the fact that we now know that the aphides can be carried enormous distances.

6. Recent Experience.

Field experience during the past three years indicates that there is developing a bunchy top conscience, and that the trouble can be overcome. The writer has in mind a plantation from which bunchy top was reported two and a half years ago in two plants originally healthy, among 22,000 plants. The owner of this plantation has

rigorously upheld the recommendation made by the Bunchy Top Investigation, and to date has lost only 50 plants out of the original 22,000. This is an indication of what can be accomplished when the grower makes the necessary effort. A still more encouraging example is that of the Currumbin valley in South-Eastern Queensland. Originally 250 men were engaged directly or indirectly in banana production in that valley. Four years ago, banana production ceased entirely owing to the ravages of bunchy top. Three years ago, the position was such that, if 1,000 plants were set out in the area, the whole lot would have contracted bunchy top within six months. During the past three years, there has been a complete cleaning up of the valley, and since two years ago about 6,000 or 7,000 plants have been put into that area on selected sites as experimental plantations by the writer.

The results are interesting. There is one plot to-day with 1,000 plants, not one of which has developed the disease; another with 300 plants in which the disease has not appeared; one with 600 plants free from disease; one with 1,000 plants free from disease; one with 600 plants in which eleven bunchy top plants appeared eighteen months ago, before cleaning up had been completed, but none has appeared since; another with 300 plants, out of which 30 developed bunchy top. The last-named plantation is in close proximity to a deserted plantation over the New South Wales border, which was only recently eradicated. All these facts indicate that, provided the necessary effort is made by all concerned, bunchy top can be eradicated.

There are certain other aspects of the bunchy top problem, such as those, for example, concerned with the other possible host plants of the banana aphis. These will be treated in a future article. Suffice it to say that they in no way interfere with the practicability of the recommendations in respect of the control of the disease.

Squirter Disease in Bananas—Preliminary Report.

By Professor E. J. Goddard, University of Queensland.

Some time ago the Queensland Department of Agriculture and Stock and the former Institute of Science and Industry agreed to co-operate in an investigation of the trouble known as "squirter" disease in bananas. Prior to that time very little was known as to the cause of the condition. The work was carried out under the direction of Professor E. J. Goddard and the necessary funds were provided on a 50 : 50 basis by the Department and the Institute, the contributions of the latter being subsequently continued by the Council.—Ed.

1. Introduction.

A disease known as "squirter" has caused serious damage to banana fruit in Australia during recent years, and notably during the past four years. In 1925, the position was sufficiently serious to necessitate the appointment of an Investigation supported by the then Institute of Science and Industry,* and the Department of Agriculture and Stock, Queensland. There is little doubt, however, that

* Now the Council for Scientific and Industrial Research.

damage due to the same cause was common enough prior to the marked development of the disease four years ago. The uncertainty with respect to the earlier occurrences of "squirter" accrues from the fact that apparently the losses in fruit were not sufficiently great to call for attention as to the exact nature of the disease, and the definite symptoms of the same. Even at the present day, it is very difficult, in most cases impossible, to obtain convincing evidence with respect to early records of the disease from any of the people connected in any way with the banana industry. This is somewhat unfortunate, inasmuch as the strong development of "squirter" within more recent years suggests the possibility of some connexion between that development and the climatic conditions obtaining in those parts where there has been a recent concentration of banana production, and which are now producing the bulk of the bananas of Australia. This statement is made merely in a suggestive way.

The disease affects bananas produced in that part of Queensland stretching from the New South Wales border as far as Gympie, and within that region it is found that the fruit from certain areas and from certain plantations is much more highly affected than that from others. A limited number of plantations are claimed to be practically immune, and while this remains a distinct possibility, yet at the same time it cannot be definitely stated that there is any plantation within the limits of the above-mentioned region which can be definitely accepted as never having produced "squirter" fruit. It has been very difficult to obtain reliable information in respect of fruit produced in New South Wales, but it is beyond doubt that "squirter" does occur. Here again, it is unfortunate that reliable records cannot be obtained, inasmuch as quantitative records would be of very material assistance. Recent information conveys the impression that "squirter" has lately affected bananas produced in Cook Islands and Norfolk Island. Beyond these areas of occurrence no record of the disease can be traced to any other banana-producing areas. It is a significant fact that "squirter" has not yet been recorded from the bananas grown in the northern portions of Queensland, that is, in the area north of the Herbert River.

The disease is strictly seasonal, and may be said to occur during the period April to October inclusive, although this period may be extended by a few weeks at either end. It is thus a winter trouble, reaching its maximum during the latter half of the period. Fifty thousand pounds would represent a modest estimate of the damage caused annually by "squirter" during the past four years in Queensland. This amount represents direct loss, but on top of this it is to be recognized that the occurrence of the disease has been responsible for setting up a prejudice against bananas during the winter period.

The symptoms of the disease are very characteristic, and the conditions are easily identified if the fruit is cut transversely or longitudinally. The name suitably describes the disease, which consists in a softening and darkening of the centre of the fruit, the whole fruit substance eventually becoming a mushy liquid which "squirts out" at the base or angles of the fruit upon slight pressure. The earliest internal symptoms are the appearance of a dark centre or core in the fruit, and the darkening of the pulp about 1 inch from the base or stem end. This is sometimes accompanied by a dark red gum-like substance in the centre of the fruit, in some instances extending in a broken or

disconnected line at intervals throughout the whole length. This affection is not restricted to any particular area, as it has been seen at times confined to the apex, while in other instances it has been observed in or adjacent to the core or cavity in the centre of the fruit pulp, at or near the stem end. These symptoms have been very carefully studied by Mr. H. Collard who, as Field Officer associated with the "Squirter" Investigation, spent a very considerable time in Melbourne carefully examining experimental consignments of selected fruit on arrival in Melbourne before and after going through the ripening process.

It is impossible to detect any signs of "squirter" potentialities in green bananas before their entry to the ripening rooms. This statement is significant inasmuch as there is at least one definite winter physiological trouble commonly known as "gumming," and the presence of which is readily determined by the external shape of the fruit Many growers still believe that there is some connexion between this gumming and squirter. Such has definitely been disproved by the Squirter Investigation. The earliest indication of definite squirter is occasionally recognized during the colouring of the outer skin of the fruit from green to faint yellow. This is discernible in the ripening room, becoming more pronounced about 24 hours after the fruit has been released from this room, and increasing in intensity each succeeding day. A very high percentage of the squirter fruit becomes a mass of decayed pulp within four to eight days after release from the ripening rooms. Thus the retail seller and the consumer are the main sufferers. All standards of fruit are affected with the disease, and in respect of the consignments of various grades of fruit from individual plantations, the percentage of affected fruit varies from a few per cent. to practically the whole consignment. The latter extreme development is, however, by no means common.

The investigations which have so far been carried out have experienced serious difficulty owing to paucity of staff, troubles bound up with the necessity for transferring fruit from train to train at the interstate borders, and the inability to secure trustworthy records in respect of temperature, humidity, &c., to which the fruit was exposed in transport, as well as the impossibility of obtaining means for setting up standard conditions of temperature &c. Fortunately, there has been set up more recently a wider organization for the investigations of squirter and allied fruit problems, and it should now be possible to secure the necessary experimental evidence. However, much valuable information has been obtained in respect of squirter, and this, as outlined below, should be of material help to the new Investigation.

2. Results Obtained to Date.

It has been definitely established that the disease is in no way associated with the presence of a bacterial or fungal organism. This statement is based on extensive pathological investigation, and on field experimental evidence. It has also been established that the rate of ripening of the fruit, and also the method of ripening, has no bearing on the occurrence of the disease.

Attempts were made in the early stages of the investigation to forward experimental consignments, utilizing the services of growers in co-operation. These consignments were taken from selected plantations, and the general supervision over a considerable number of

plantations thus employed was exercised by the Field Officer. The scheme was also dependent on reports from the agents to whom the consignments were forwarded in Melbourne. Each plantation was equipped with a number of maximum and minimum thermometers, and each was also divided into definite sections so that fruit, representative of highland and lowland sections, and so on, was kept under observation. While much help was forthcoming from some of the growers, others failed, and the response from the agents was equally unsatisfactory. This same difficulty has, I think, been experienced by other investigators, and there can be little doubt that leasing of plantations or orchards, and the employment of reliable staff, is essential for such work. More recently an attempt was made, in view of the fact that all the evidence indicated that the squirter was definitely a physiological disease, to have control over the complete output of a plantation on which were growing plants of various ages, and which, after a careful survey, was divided up into sections and subsections, for each of which arrangements were made in respect of daily temperature records, &c. All the fruit from each plot was cut, handled, packed, and branded separately under the personal supervision of the Field Officer. No results are available from this experiment.

Towards the end of 1927, fruit was selected from several plantations in Northern Queensland in the neighbourhood of Innisfail, and also from several plantations in South-Eastern Queensland. Each consignment, on reaching Brisbane, was divided into four sections so that from each plantation there could be sent fruit via the inland New South Wales railway route to Melbourne, fruit via Tweed Heads and Sydney by railway to Melbourne, fruit by boat from Brisbane to Melbourne, and fruit retained in Brisbane. A large number of these consignments was available, and the results are very decisive. In every case it was found that squirter appeared in bananas sent from plantations in South-Eastern Queensland to Melbourne, independent of the route over which they were transported, and in no case was squirter ever detected in bananas from Northern Queensland. The following table sets out one of the comparative tests:—

A Case of Bananas from Northern Queensland.

Date Examined.	Number of Bananas Examined.	Number of Squirter Bananas.
17th August, 1927 ..	177	Nil
18th August, 1927 ..	152	Nil
19th August, 1927 ..	50	Nil
22nd August, 1927 ..	184	Nil
Total ..	563	Nil

A Case of Bananas from South-Eastern Queensland.

Date Examined.	Number of Bananas Examined.	Number of Squirter Bananas.
17th August, 1927 ..	20	11
18th August, 1927 ..	103	79
19th August, 1927 ..	117	70
22nd August, 1927 ..	137	63
23rd August, 1927 ..	236	115
Total ..	613	338

This sample test is one of a large number in which comparisons have been made, employing bananas from Northern and South Queensland which have travelled by the same train from Queensland to Melbourne, placed in the same day in the same ripening room, ripened under same temperature and air conditions, and withdrawn from the ripening rooms on the same day. The indication is definite enough that climatic conditions constitute a factor at least in causing squirter. That aspect is at present the subject of investigation. It is important to bear in mind in this connexion that banana production in Queensland is affected to a very large extent in areas where winter temperatures might well seriously affect a plant which is of tropical origin; but it would be unsafe to pronounce definitely, on the temperature factor, inasmuch as other weather conditions, such as winter rainfall, for example, call for consideration. Much more investigation is necessary, and reliable meteorological data must be available for further elucidation of the problem raised by these experiments.

One other interesting aspect of the general problems calls for mention, in that it has not been found possible to produce squirter in any of the bananas retained in Brisbane. In fact, in the present state of our knowledge, one is justified in saying that squirter is unknown on the Brisbane markets. Attempts have been made by setting up temperature conditions corresponding to those experienced by fruit *en route* to the south, to produce squirter in Brisbane, but no success has been forthcoming. This indicates that the problem is by no means so simple after all, and that transport conditions constitute another factor in the problem. In the present state of our knowledge it would appear that fruit grown in certain parts, namely, in South Queensland, suffers during the winter period under a physiological disability which responds to unsuitable temperature or other conditions during transport in the development of the condition known as squirter. We know from the results of investigations carried out in other parts of the world, that conditions of humidity and temperature must be satisfied in the successful transportation of bananas, and we know equally well that the conditions in those respects in Australia are quite wrong. Consequently, a correction may yet be applied in transport conditions which may offer a solution to the squirter problem. However, the fact that bananas produced in Cook Islands, and possibly Norfolk Island, are at least under suspicion for squirter, strongly suggests some other remedy as necessary. It is premature to pronounce at this stage, but from what has been stated above, it will be appreciated that inasmuch as the trouble makes its appearance during the period of conversion of starch into sugar, and that squirter does not make its appearance in bananas ripened in Brisbane, and further, that the trouble occurs only during the winter months, there is much reason in the suggestion that a partial ripening of the bananas prior to despatch from Queensland might offer a solution. We now know that scientific ripening as practised in America under standard conditions of temperature and humidity, not only produces a better coloured and better type of fruit, but also that the banana, when properly ripened, can, especially during winter time, stand up against decay for a period of about three weeks. This statement is based on actual experiments. This may offer the ultimate solution of the problem, but, as stated above, further investigation is necessary.

Some Notes on Modern Ceramic Kiln Practice and its Trend in England and Czecho-Slovakia.

By R. C. Callister, formerly officer in charge of the Council's Ceramic Investigations.

Having recently been given the opportunity to observe many kilns of both older and modern types in operation, some references are made in this paper to some of the variations in practice observed, and, where possible, to improvements noted in regard to their structure and use. With various recent developments in regard to the ceramic industries and their markets compelling increased attention to be paid to all processes of manufacture and to the elimination of waste in some of its many aspects, some of the fuel burning methods which are applied to the production of fired wares will also be briefly reviewed.

The fuels in use consisted of (i) oil, (ii) producer gas, and (iii) solid fuels, such as lignite, brown and black coals and gas coke. Occasional references to the use of wood as a fuel were made, but no example of its use was observed, and whatever its advantages or limitations it is now practically not available in the European countries in question.

The products of combustion from these fuels, as heated gases, are utilized in a variety of types of kilns, among which are included—

(*a*) periodic kilns, up and down draught, round and rectangular;
(*b*) continuous ring kilns with a moving fire zone;
(*c*) chamber kilns, also with a moving fire zone and both semi-continuous and continuous in operation;
(*d*) tunnel kilns, in which the fire zone is stationary while the ware passes at a pre-determined rate through this zone, and which are necessarily also of the continuous type;
(*e*) rotary continuous kilns firing magnesite; and
(*f*) various modifications of the muffle kiln.

Incidentally, in England, only muffles are regarded as kilns, those other types in which the ware is fired by direct contact with the gases of combustion, or in which the ware is protected from these gases only by enclosure in saggers, being regarded as ovens.

(*a*) *Periodic Kilns.* The present day types of up and down draught kilns have been slowly evolved as a result of a great many trials and observation as to the firemouth and flue arrangements and sizes, and the limiting sizes of the kilns have been arrived at in the same way. In spite of the great attention to these details and the expenditure of much ingenuity in directing the flow of the hot gases, this type of kiln is wasteful of fuel, as the walls, crown, floor and flue brickwork, as well as the saggers and the ware, are heated up and then all this heat is dissipated to no useful purpose during cooling. In addition the gases are discharged as waste while containing a vast number of heat units. Such ovens are also contributors to the smoke nuisance, while they still represent by far the largest number of producing kiln units. Skilful firing gives quite uniform firing conditions and a satisfactory quality of wares, and for small and variable outputs this type will be hard to displace by others. While the size and interior design has been closely determined for the varied uses to which these kilns are put, their ultimate design and construction and

the methods of using them have not been by any means finalized. For instance, a considerable improvement has been effected by attending to the insulation of some of these kilns, while in the case of some of the heavier wares, particularly common and fire bricks from which large volumes of water have to be removed as steam, the assistance of accelerators in removing this steam and shortening the water smoking period has also proved of value. The accelerators are portable electrically driven fans which withdraw large volumes of gas and steam from above the floor of the kiln, either through the clammings or through a specially built-in outlet pipe or from the main flue, and discharge it directly into the atmosphere, thereby relieving the chimney stack, lessening the risk of condensation, improving the draught and shortening the early water smoking phase. Towards the end of operations, i.e., while cooling, by reversing the direction, air can be forced in to expedite the cooling. The accelerators cost approximately £80 in England, and the cost for electric power while running is a few pence per hour (1s. 6d. a day), while the result of the use of the accelerator was in some cases to lower the kiln cycle to three days in sixteen.

The insulation referred to above was obtained by the use of insulating bricks of the diatomaceous earth type in which the pores are exceedingly minute, in place of previous efforts with very thick walls, and the result was that heat transfer was greatly slowed down and the loss by conduction reduced. In some cases, usually with new kilns, the structure was fully insulated, in others only the crown was done, but it appeared desirable that the floor and crown be well insulated even if the walls are not done. The practice of keeping the insulating brick separate from, that is not bonded with, either the fire or common brick is followed, though not universally. On one works the walls were built of 9 inches of firebrick, 4½ inches insulating brick, and 18 inches of common brick, while on the 9-inch firebrick crown was a 3-inch layer of insulating brick, and below the firebricks of the bottom was another 3-inch layer of insulating brick. This resulted in a large saving of fuel because of reduced radiation losses and the shortening of the kiln cycle from eleven to seven days, while a very much more uniform ware was produced, though the finishing temperature was approximately 1200°C. An earthenware glost oven 19 ft. 6 in. diameter, and 16 ft. high, and fully insulated was placed one day, fired next day, and cooled on the third as a regular practice, and because of the greater uniformity of the heat treatment an increased quantity of ware was set and fired each time, with a saving of fuel of approximately 25 per cent.

Earthenware and china kilns are tall by comparison with those in which salt glazed pipes are fired, though the latter, when round, often have a larger diameter, and in many cases they are further modified in that they have a central stack. Some of the recently built earthenware biscuit and glost ovens have been erected without hovels, while practically the maximum size for kilns for sagger enclosed ware is a diameter of 20 feet and a height of 16 feet. The two-storied porcelain ovens of the Continent utilize the otherwise waste heat of the gases from the glost and maturing lower chamber to fire the biscuit in the upper chamber. As the crown of the lower chamber is practically the floor of the upper one, the lower chambers are flatter and so carry lower bungs of saggers than do the earthenware ovens. The differences in the ware placing practices with the two types are very marked.

The use of lower grades of fuel in the earlier stages of firing results in a lowering of fuel costs. The good coals are reserved for finishing purposes. In this connexion some of the slack coals in England and of the brown coals in Czecho-Slovakia are very unpromising as fuels when judged on appearance, but their extended use is a sufficient corrective of this impression. Some crude oil firing of the intermittent type of kiln was practised in England both during and after the coal strike of 1926. Of course a number of initial difficulties had to be overcome, but apparently the effort proved successful, even though the cost of the oil fuel consumed was appreciably higher than the equivalent coal required. The economy in its use followed several beneficial results, including (*a*) better flame control, both as to length of flame and the associated air supply, (*b*) less rejects through development of flaws in the goods, (*c*) smaller sagger loss, and associated with this greater capacity for goods, (*d*) better glaze appearance, and (*e*) a rather shorter firing period, again increasing output. In short an improved time temperature curve and better pyrometric control was obtained.

At Rakonitz, in Czecho-Slovakia, a range of round periodic tile kilns firing tile biscuit to 1180° C. have recently been converted to producer gas firing, the gas being conducted to the kilns from a central producer.

While, as stated earlier, these intermittent kilns have contributed largely to the smoke nuisance and are wasteful of fuel, the practice largely obtains in England, though not on the Continent, of building them in the open and leaving them and their attendants exposed to all weathers and further handicapped by this procedure, whereas other types are housed. To their disadvantage is also the labour of setting the ware in tall bungs, from ladders, with increased load on and strains in the saggers, and so an added loss. Separate placing benches are necessary, and there is the comparative awkwardness of two-way traffic through the narrow entrance. Also, although it is realized that rapid cooling from 1100°C. to 700°C. results in little harm to the kiln contents, there is little real knowledge of the subsequent cooling conditions, and little control is attempted except perhaps to hasten the cooling sufficiently to enable access to be given to the goods. The resultant heating and cooling strains are detrimental to the kiln, and a good deal of upkeep expense is unavoidable. The disadvantages appear to be offset by the flexibility of these kilns as to use, output, variety of wares, and by the wide experience of them held by the industry.

All types of wares are fired in these kilns, from the commonest right through to the highest grades. The firemouths of the kilns used in England are mainly designed to make it easy to maintain oxidizing conditions, while in the porcelain kilns of the Continent as the high finishing temperatures are approached, mildly reducing conditions are produced.

Very few pyrometric installations were noticed in use with these kilns, though some form of heat treatment indicator such as cones, rings, and bars is in common use, but generally the final control and finish is gauged by draw trials.

(*b*) *Ring Kilns.*—While the moving fire zone kilns of the Hoffman type are widely used in burning bricks, one or two burning roofing tile and some in use for lime burning were also seen. When these kilns were used for firing plastic and stiff plastic bricks, accelerators were in

frequent use, resulting in a saving of time and fuel and marked acceleration of the water smoking process. These kilns are very prone to produce scummed bricks as a result of condensation of water on the coolest bricks. This water dissolves SO_2 and SO_3 from the gases, and the resulting H_2SO_4 prior to evaporating later at a comparatively high temperature causes a lost of scumming.

These kilns are usually substantially built and involve a higher first cost, and should be operated to their maximum capacity to be most economical. Very often the warm air rising from such kilns was used for drying purposes. In England, the $\frac{1}{2}$-in. coal fuel was observed to be always hand fed, but in Czecho-Slovakia and Austria some mechanical stokers are at work, and a saving of 30 per cent. of fuel and firing expenses is claimed as a result. Many of these kilns operate at the quite low temperature of approximately 1000 deg. C., and the highest temperatures were observed in the lime kilns, where 1250 deg. C. was reached. The upkeep in the latter case was considerable.

(*c*) *Chamber Kilns.*—This type is also not a recent development, though some of the modifications are. They were seen in use for the firing of firebricks, silica and magnesite and glazed bricks, earthenware, terra cotta and sanitary wares. Some of the heat treatment given to the wares was severe, and temperatures of 1350 deg. C., 1380 deg. C., 1420 deg. C., and 1650 deg. C. were noted in different units. In some cases solid fuel was fed into the chambers among the ware, but in other cases producer gas was used. The secondary air is preheated by the cooling ware, while the gaseous products of combustion yield much of their heat content to the unfired ware in chambers ahead. The solid fuel used was coal, while the producer gas was obtained usually from coal, though in some cases brown coal was utilized. Even the semi-continuous type effect a marked economy in fuel as compared with an equivalent output from periodic kilns, and this saving is increased when portion of the cooling waste gases is withdrawn to assist in drying ware in a tunnel dryer. The fuel consumption in one large semi-continuous kiln is only one-third what it is for equivalent output in the round intermittent down-draught type, while in a continuous chamber kiln of another type, producer gas fired to 1280 deg. C. the figures were quoted of just over 4 tons of coal for a given output compared with 26 tons when the muffle-type kilns were used. In addition, the rejects or losses in this Shaw-type kiln were stated to be below 1 per cent. In many cases these kilns were equipped with recording pyrometers and with draught gauges, and they were worked to a carefully predetermined time temperature curve. They were under control and capable of burning different wares to different finishing temperatures in successive compartments. Also, in the cases of those fired by producer gas where various glazed products such as sanitary ware, terra cotta, glazed bricks, and electrical porcelain were fired unenclosed except by the chamber, i.e., not set in saggers, the ease of setting and drawing, and the simplicity and robustness of such supports as were necessary, together with the uniformity of the product and the smaller amount of material to be heated (no saggers), resulted in economical use, while, in addition, smoke was eliminated as a nuisance.

Where producer gas is used in these kilns in England, it is obtained from long flaming coals of a fairly uniform rather small size, in large producers with a steam injection at about 60 lb. per square inch.

Successful control is exercised in at least one instance by control of the temperature of the outgoing gas, which is not scrubbed. Large and tall chimney stacks are used, and a good deal of careful patient observation and adjustment is necessary to obtain uniformity of heat conditions and to eliminate zones in the chambers when the kilns are first put into commission. The number of chambers varies, with 14-16 common for the continuous and 5-8 typical of the semi-continuous kilns. The sizes of the chambers vary from 14 feet x 6 feet x 10 feet to 23 feet x 11 feet x 13 feet, according to requirements, but some quite small ones have been successfully used, though the tendency is towards even larger chambers. So far the use of insulating material is very limited in its application to these kilns, and the materials used for lining vary with the finishing temperatures and conditions from firebrick to high aluminous bricks to silica bricks, and in the case of the firing of magnesite to 1650 deg. C., magnesite bricks were used as the lining material.

The kilns are robustly built and usually well braced and strapped, and upkeep is not large until efforts are made to soak wares such as semi-silica and silica bricks at temperatures such as 1380 deg. C. and higher. In a 14 or 16 compartment kiln approximately three days are available in which to effect repairs, and if these are not then completed the kiln is not necessarily held up, as the one chamber can be missed, though it must be closed and follow the kiln cycle.

The producer gas used in Czecho-Slovakia for kilns of this type was derived from brown coal. In one installation firing was to a temperature of 1450 deg. C., and the gas was obtained from several large producers of the rotating-grate type in common use there.

(d) Tunnel Kilns.—These are straight line kilns of great lengths of up to 350 feet or more. They are of two general types, i.e., muffled and direct fired, and are practically a latter-day development, and of them the most prominent are the Dressler, Harrop, Faugeron, and E.I.C.T. kilns, though there are still others which differ from the above in various respects. These kilns are by no means completely developed, as improvements are constantly being effected. Yet quite early kilns were in some cases very efficient for their designed purpose. Later ones have larger cross sections and bigger outputs, and obtaining these outputs from the large horizontal flue which constitutes the kiln has brought other troubles. This type of kiln is essentially one for dealing with a large and continuous output and for mass production. It lends itself also to arrangement of plant with this end in view, but is not suitable for cramped quarters, and, wrongly placed, can largely isolate portion of a works. Quite large numbers are now in use, as the following rather approximate figures show, viz.:—United States of America, 100; Germany, 40; France, 10; while in England the Dressler people have erected 38, and a number of other types referred to are in commission. The muffle type is used for firing glost ware of a wide variety of types, including stoneware, wall tiles, fire tiles, and general earthenware, and though they operate with great regularity for long periods, neither in design nor operation are they so simple as might at first appear. The use of carborundum refractories in the hot zone has lessened one set of troubles, and with many of these kilns were operated induced draught producers using gas coke as fuel and effecting large fuel economies. In one Dressler, alternate trucks were loaded

with biscuit and glost ware and fired to 1140 deg. C. in both cases. These kilns are not so far generally used for firing refractories, but for stoneware (once fired), wall tiles, and for glost firing potteryware they are extensively used, and their use is being extended. Their use for firing sanitary ware is still very limited, except in the United States of America. When the number of cars per day is increased it is often necessary either to prolong the maturing zone, or to raise the temperature, while these adjustments can also provide a remedy for crazing, or increase the margin of safety against crazing.

These kilns are all fitted with and largely controlled by pyrometers, and they usually operate to a time temperature curve which has been proved effective with the ware fired. The use of cones on each truck seems universal, and the cones are the finishing control. Tunnel kilns are well insulated.

Direct-fired tunnel kilns for clay refractories have not yet been adopted in England, partly because all the English materials contain carbonaceous matter and because the data on daily output, on upkeep at temperatures of about 1400 deg. C., and on the uniformity of the heat treatment when the cross section approaches 6 feet x 6 feet has not convinced prospective users of their suitability. When the cross current, regenerative, alternate direction of gas flow, double track, direct-fired kilns develop further, they will enlarge the scope of the tunnel kiln, and possibly even interest makers of common bricks.

The capital outlay and the space required, together with an output limited to some 50 tons per day, have so far prevented their use in such production.

Two of the difficulties facing would-be English users are (*a*) that their ball and fireclays contain up to approximately 10 per cent. of carbonaceous matter, which is difficult to remove satisfactorily and more so from larger pieces; and (*b*) that if the cross section exceeds 5 feet square and more particularly if the effective height above the truck platform exceeds 5 feet, then zones occur and uniformity is not obtained. As a height of 6 feet is desired to give the most economical setting with large sanitary ware this is, at the moment, a serious drawback, and this although such ware is being fired in tunnel kilns in the United States of America. In direct-fired tunnel kilns, oxidizing atmospheres are required while carbon is present, and usually in England all through the process and the larger volume of gases then involved, when raised to high temperatures, make extra provision for their movement a necessity.

Tunnel kilns are successfully firing firebrick, semi-silica and silica brick in Europe, and their use for similar purposes in England is under consideration, or is arousing active interest and inquiry. One was observed at Radenthein in Austria, in which magnesite bricks were fired to 1650° C., the trucks taking five days to pass through the kiln. The producer gas in use was obtained from black coal. Gas coke is largely used in the producers, especially for firing wall tiles, and in Czecho-Slovakia glost temperatures of 1050° C. were maintained by the use of brown coal in rather large producers with revolving grates, the whole being over a water seal.

The direct-fired E.I.C.T. kiln may be operated really as a semi-producer. In one such producer it was noticed how an insulated hot zone resulted in the burning out of best quality firebricks. When the

insulation behind the firebricks was replaced by an air flue, it resulted in better firebrick life and a preheating of some secondary air. This type of kiln has an inspection tunnel below the trucks, and warm air is drawn from this tunnel and utilized. The insulation of the truck bottoms is effective, and no sand seal is used with the muffle type. All the available heat is not removed from the ware as it issues from the average tunnel, and cooling off arrangements are usually provided separately. As mentioned above these kilns are being constantly modified and improved, for instance reversible, cross current, regenerative tunnel kilns are being developed to permit of greater cross sectional area and output and to increase uniformity throughout.

Other smaller types are in use in Czecho-Slovakia for enamelling and decorating purposes, but the temperatures reached are only from 750°-900°C.

In England the Climax kiln has served a similar purpose, but recently several electrically heated tunnel kilns have been put in commission for firing and developing the decorations. These operate at about 850° C., and are heated through the medium of resistance wiring. The tunnels are some 82 feet in length and with a small cross section of approximately 1 foot x 1 foot. The resistance wire is placed on the inner surface, and sections are replaceable without stopping the whole current input, which, of course, is normally under control, so that the temperature is easily controlled and cleanliness is easily maintained.

One of the most interesting of all the recent developments has been made possible by the development of a stable ceramic electrode by C. W. Speirs, of The Morgan Crucible Company, Battersea. This electrode is made in a variety of shapes and sizes, the largest flat pieces being 7 feet x 1 foot x 1 inch, and these flat electrodes are of a suitable size for use in tunnel kilns of small cross section as now in use in London and in Sweden. The kilns in use in Sweden have been described by A. S. W. Odelberg and C. W. Speirs, and while still little beyond the experimental stage they are turning out large quantities of china glost cups, satisfactorily fired week in and week out to 1100°C. The glost firing of flat ware is being tried out, and it is probable that china biscuit firing will soon be practised, and this will require the maintenance of 1300° C. The energy input is all electrical, and a further improvement consists in running two parallel adjacent lines of trucks, but in opposite directions, while for certain wares the carrying platforms are caused to rotate. The electrodes have a life of approximately three months, and are then easily replaced. The first cost is comparatively small, the space occupied is not extensive, and the output is comparatively large owing to the rapid firing schedule. The atmosphere is clear and controllable, rejects are greatly reduced, very considerable uniformity of conditions is obtained, and upkeep appears to be reasonably small. Where cheap power is available, this type of kiln appears to offer considerable scope, especially to factories with an output not large enough to utilize the Dressler type kilns to full capacity, yet to all appearances it has aroused very little interest in England, which is a matter of some surprise.

(*e*) *Rotary Kilns.*—Two examples of large rotary kilns were those in use at Veitsch and Radenthein, in Austria, for calcining or dead burning magnesite. The finishing temperature of 1650°C. was obtained

by the use of pulverized Silesian black coal. This coal was high in ash, and as the fuel used was about 30 per cent. of the weight of calcined magnesite the ash introduced was considerable, but most of it was claimed to be recovered as dust. These kilns, though differing in design, were some 300 feet long and 10 feet in diameter, and had a daily output of above 200 tons per day. The linings from the cooler end were firebrick, best firebrick and magnesite in that order, and the magnesite lining was expected to last three months. Extensive dust collecting systems were in use in connexion with these kilns, which have many advantages by comparison with the batteries of shaft kilns formerly in use. It is worth noting that the product is very high priced.

(f) Muffle Kilns.—Besides the ordinary coal fired muffle kilns in wide use for decorating purposes to temperatures of 850-900°C., a number were also seen in use for the firing of terra cotta to from 1180-1250°C. These latter were rather small, only set with ware to a height of some 7 feet 6 inches, and with a central stack to assist in maximum utilization of the heat and for uniformity, but these kilns are inefficient by comparison with the gas-fired chamber kilns referred to earlier, as the latter require less fuel, labour and time for probably better results.

A further development of the carbon resistor electrode referred to above is a laboratory type of muffle, electrically heated of course, which has been evolved at Battersea. The muffle, with the transformer and all fittings costs roughly £70 when packed for despatch at Battersea. In it a temperature of 1400°C. can be obtained and 1350°C. can be maintained. The electrode has a life of eight to ten weeks of continuous use or 30 heats to 1350° C. if used intermittently, and the London cost of replacement is £3. The running cost is approximately 1s. per hour (at 1d. per unit), and any desired atmosphere can be maintained, while the rate of rise of temperature is conveniently under control. The possibilities for the extensive use of muffles of this type appear very great, though so far their use is still very restricted.

The Poison Plants Committee.

The following article comprises practically the whole of the 1st annual report (for the period July, 1927, to December, 1928) of the Poison Plants Committee of the Council. The Committee controls work in which various branches of the New South Wales Department of Agriculture, the University of Sydney, and the Council are co-operating.—Ed.

1. General.

The Poison Plants Committee was originated by the Council for Scientific and Industrial Research as a sequel to a resolution passed by the Australasian Association for the Advancement of Science at Perth in 1926. The Committee is honorary, and was formed by the Council primarily to assist the pastoral and farming industry by co-ordinating and amplifying work already being done, particularly at Glenfield, New South Wales, on the investigation of the known and reputedly poisonous plants which cause in some seasons serious losses of stock by poisoning.

A tribute is due to the initiatory work of Professor J. Kenner, D.Sc., F.R.S., who acted as Chairman of the Committee from its inception until his return to England at the end of 1927. It was a disappointment to Professor Kenner and to the members of the Committee that he was not able to participate further in the work which he so enthusiastically began. On the departure of Professor Kenner, Mr. H. Finnemore was appointed Chairman.

The constitution of the Committee is given below—

H. Finnemore, Esq., B.Sc., Department of Pharmacy, University of Sydney (Chairman).

Professor H. G. Chapman, M.D., B.S., University of Sydney. (Resigned June, 1928).

Dr. B. T. Dickson, B.A., Ph.D., Chief, Division of Economic Botany, Council for Scientific and Industrial Research. (Appointed June, 1928).

Professor J. C. Earl, D.Sc., Ph.D., F.I.C., Department of Organic Chemistry, University of Sydney. (Appointed March, 1928).

Colonel Max Henry, M.R.C.V.S., Department of Agriculture, New South Wales.

Professor J. Kenner, D.Sc., Ph.D., F.R.S., University of Sydney. (Resigned December, 1927).

Professor T. G. B. Osborn, D.Sc., University of Sydney. (Appointed April, 1928).

Associate Professor H. J. Priestley, M.D., Ch.M., B.Sc., University of Sydney. (Appointed July, 1928).

Dr. H. Seddon, D.V.Sc., Glenfield Veterinary Research Station, Department of Agriculture, New South Wales.

Dr. G. P. Darnell Smith, D.Sc., Botanical Gardens, Sydney.

The Secretary of the New South Wales State Committee of the Council, Brigadier-General I. G. Mackay, acts as Honorary Secretary to the Committee.

Associated in this work with the Council for Scientific and Industrial Research are the University of Sydney and the New South Wales Department of Agriculture. The former supplies the facilities and laboratory accommodation of its Departments of Organic Chemistry, Physiology and Pharmacy, whilst the Department of Agriculture contributes through the facilities at the Research Station at Glenfield and the Herbarium of the Botanic Gardens at Sydney. The funds for carrying on the work are supplied by the Council, which has made a grant of £1,050 for the first year for this purpose. This provides for the payment of one part time and two full time research officers working at the University, and defrays the cost of animals and material used at Glenfield Veterinary Research Station.

Subdivision of the Work.—The subdivision of the work was arranged according to the following scheme which is intended to be sufficiently elastic to allow a member of the Committee to undertake and supervise work, not specifically in his department, in which he has some special knowledge:—

	Where Experiments are Performed.
1. Veterinary Field Officer's report of mortality of stock.	
2. Collection of material and its botanical identification	Field officers and Botanic Gardens.
3. Feeding experiments	Glenfield.
4. Extraction and classification of poisonous principles	Department of Materia Medica and Pharmacy.
5. Chemical study of the active principles ..	Department of Organic Chemistry.
6. Pharmacological experiments	Department of Physiology.

Meetings of the Committee are held monthly at the Royal Society's House. This opportunity is taken to express the thanks of the Committee to the Council of the Royal Society of New South Wales for permission to use their rooms.

Dissemination of Information.—As soon as a plant is found to be toxic, information is sent to the Director of, or Under Secretary for, Agriculture in all States of the Commonwealth, additional copies being forwarded also for transmission to the Chief Veterinary Surgeon, and the Government Botanist, Plant Pathologist, or corresponding officer. The Committee expresses its sincere appreciation of the co-operation it has received from all the States by the provision of information and of botanical material, from widely different areas.

Herbarium Specimens.—In order that the botanical material may be available later for reference and possibly for exchange, it has been arranged that specimens of all plants found to be toxic shall be kept. These will be transferred to the proposed National Herbarium at Canberra when facilities for their storage are available.

Research Officers.—Two whole-time paid workers have been appointed during the year—Mr. C. B. Cox, B.Sc. (Sydney), who was appointed in January, 1928, to work in the Pharmacy Department under the direction of Mr. Finnemore and Mr. A. A. Luciano, B.Sc. (Sydney), who commenced work in August under Professor Earl in the Department of Organic Chemistry. In addition, Mr. Horsley, B.Sc. (Sydney), has been engaged half time in pharmacological problems in the Physiology Department, first under Professor Chapman, and later under Professor Priestley.

Veterinary Field Officers' Reports.—Reports of mortalities amongst stock are regularly forwarded to the Chief Veterinary Surgeon, Department of Agriculture, the District Veterinary Officers collating the reports furnished by Inspectors of Stock under their control.

When it appears from the reports received that any plant may be incriminated in the mortality, the question goes forward to the Poison Plants Committee, and arrangements are made for the collection of the necessary material by the field officers of the Department referred to.

2. Botanical Identifications.

Since 1st January, 1928, 229 collections have been received from Glenfield. Of this number, 114 specimens have been identified as *Euphorbia Drummondii* or forms of this species; 12 have been determined as "variegated thistle" (*Silybum marianx*); 11 as *Indigofera australis* or forms of this species; 9 as *Swainsonas,* and 7 as *Lotus australis,* or forms of this species. Special investigations are in progress in an endeavour to work out more definitely the recorded varieties of these genera.

In addition to those mentioned above, there are representatives of 33 genera, the specific names of which have been furnished in our reports. The rumen contents of stomachs from 23 animals have also been examined, and details of the results of our determinations have been furnished. Quite apart from the reports on plant specimens received from Dr. Seddon, we have also examined a number of specimens submitted by Mr. H. Finnemore, which have included *Goodia lotifolia, Goodia pubescens* (?), *Lotus australis* var. *pubescens, Physalis peruviana, Hakea dactyloides,* and *Acacia Georginae.*

Specimens of 81 species of *Acacias* have been furnished from the Herbarium and Gardens for testing purposes, also specimens of *Goodia lotifolia, Poranthera microphylla, Poranthera corymbosa, Poranthera ericifolia, Pultenaea polifolia, Pultenaea viscosa, Boussingaultia baselloides,* and *Eucalyptus cladocalyx.* Information has also been supplied concerning the geographical distribution of *Acacia doratoxylon, Poranthera microphylla, Poranthera ericifolia,* and *Poranthera corymbosa.*

3. Veterinary Research Work.

The work undertaken at Glenfield has comprised the following:—

(*A*) Organization of supply of material.

(*B*) Investigation as to toxic properties—

- (*a*) Cyanogenetic plants;
- (*b*) Investigations as to toxicity of hydrocyanic acid and of saponins;
- (*c*) Field investigation on Darling pea, &c.

(*A*) Organization of Supply of Material.

Most of the plants to which attention has been directed during the past year are plants which had already been marked down for attention as opportunity offered, though some of these were investigated at the special instigation of the Committee; a few were brought before us for the first time by reason of the fact that field officers of the Stock Branch of the Department of Agriculture had found them apparently (or possibly) responsible for loss in stock.

In collection of this material the greatest assistance has been furnished by District Veterinary Officers and Stock Inspectors who have personally collected about 300 specimens and made arrangements for local residents to forward bulk supplies where such were required for feeding tests. In only odd cases has it been necessary for us to make arrangements with collectors ourselves.

The necessary arrangements were also made for the systematic collection of specimens of *Euphorbia Drummondii, Silybum mariana,* and *Indigofera australis;* and later some specimens of *Goodia lotifolia* were arranged for.

The material thus coming forward to Glenfield has been dealt with as follows:—

(i) Specimens of every supply have been referred to the Director of the Botanic Gardens, Sydney, for identification.

(ii) Supplies specially arranged for chemical testing for HCN have been forwarded to Mr. Finnemore.

(iii) Bulk supplies have been used for feeding tests at Glenfield.

(iv) Certain bulk supplies have been sent to the University for further study there.

(*B*) Investigation as to Toxic Properties of Plants.

In all cases where definite information is required as to whether a plant is toxic or not, feeding tests are undertaken. For this purpose, animals are used of the same species as that said to be affected by the plant under natural circumstances, with, in addition, feeding tests on other species of domesticated animals.

Plants dealt with during the year.—The plants, &c., so dealt with may be considered in order, the result being summarized briefly. In addition it may be mentioned that in connexion with so-called Gidyea poisoning in Queensland, we examined tissue from an animal that died, but no lesions to which death might be attributed were detected.

(a) Cyanogenetic Plants.

(i) *Acacia glaucescens* ("*Sally Wattle or River Myall*").—This wattle having a reputation locally for poisoning stock, feeding tests were undertaken on cattle, sheep, and pigs. The plant was found to be highly toxic, and the circumstances, symptoms, and post-mortem findings pointed strongly to the effect being due to HCN. (Specimens of the tree and of ingesta were therefore submitted to Mr. Finnemore, who confirmed the presence of HCN in the material.) Bulk supplies were obtained for Mr. Finnemore and other specimens provided.

(ii) *Euphorbia Drummondii* (*"Milk Weed"*).—This plant has commonly been suspected by owners, but owing to the fact that some years ago Stanley had fed the plant to sheep without ill effect, and also that another plant has been mistaken for the above, it had been felt that there were grave doubts as to whether it were actually poisonous. Owing to this somewhat unsatisfactory position, bulk supplies were obtained from four districts and tested on sheep, when it was found that one of these supplies was toxic. The animal tests indicated that the effect was due to HCN, and on testing chemically Mr. Finnemore was again able to confirm the suspicion. The collection of specimens from all parts of the State was then arranged for.

(iii) *Sorghums, Sudan Grass, and Hybrids.*—In order to provide material for chemical testing a plot of ground was sown with 36 different varieties, the seed being provided by the Agrostologist of the Department of Agriculture.

(iv) *Indigofera australis* (*"Wild Indigo"*).—This plant having been shown by Ramsay to be cyanogenetic, arrangements were made for Stock Inspectors to forward regularly specimens for chemical testing and a large quantity of material was collected locally for the same purpose. At the same time feeding tests were conducted, as the effects commonly attributed to this plant are not those of HCN poisoning.

(v) *Silybum mariana* (*"Variegated Thistle"*).—Arrangements were made for the regular collection of specimens by Stock Inspectors in order that they might be tested for HCN—the clinical evidence strongly suggesting that the plant is cyanogenetic.

(vi) *Halorrhagis sp.*—This plant came under suspicion in connexion with mortality in stock, and on submission to Mr. Finnemore was found to be cyanogenetic. A supply from another source was similarly found to be cyanogenetic.

(vii) *Lotus australis* (*"Native Bird's foot Trefoil"*); *Goodia lotifolia* (*"Clover Tree"*).—Arrangements were made for the collection of supplies of these plants in order that they might be tested chemically.

(*b*) *Toxicity of Hydrocyanic Acid and Cyanogenetic glucosides.*

(i) Incidental to the above, it was felt that additional information was desirable as to the toxicity of HCN. Sheep were chosen for this work, and the supplies of HCN and of cyanogenetic glucoside used were standardized chemically by Mr. Finnemore. The work is still in progress.

(ii) *Tests of "Saponin."*—As we feel grave doubt as to the actual harmfulness of saponins to stock certain studies have been initiated in this direction in collaboration with Professor Earl.

(*c*) *Plants known to be toxic, but upon which further information is desired.*

(i) *Stachys arvensis.*—In order to supply material for physiological study, some sheep were fed at Glenfield, and the symptoms, &c., were observed by Professor Priestley. Blood specimens were supplied for certain determinations. A supply of ether extract (found by us to contain the active principle) and also seed, were supplied for physiological study.

(ii) *Isotropis atropurpurea.*—Certain extracts and residues prepared by Mr. Finnemore were tested upon bovines, the material being controlled by the administration of the untreated plant to another animal. The work is temporarily suspended pending receipt of further plant material.

(iii) *Atalaya hemiglauca* (*"Whitewood"*).—This tree has recently been incriminated by Murname and Ewart, who hold it to be the cause of Kimberley horse disease. They worked with supplies from Western Australia, and as the tree grows in New South Wales also, it was felt desirable to test supplies collected in the latter State. The feeding tests have been going on for some time, but are not yet concluded.

(iv) *Hypericum perforatum* (*"St. John's Wort"*).—It has been previously established by Rogers, and confirmed by Dodd and Henry that the ingestion of this plant in the flowering stage causes photosensitization leading to dermatitis on exposure to the sun. It having been suggested that the plant might be grazed with safety when young, feeding tests were undertaken, when it was found that the plant possesses the same property during the pre-flowering stage. A field investigation by Mr. H. G. Belschner, District Veterinary Officer, showed that it could not be controlled by this means, both on account of its harmful properties, and the fact that grazing does not kill it. Further tests have been undertaken on sheep with a view to studying its effects more closely, and devising a suitable protective dressing which might be used in connexion with other plants having the same property.

(v) *Swainsona spp.* (*"Darling Peas"*).—A field investigation was undertaken by Dr. Seddon in company with Mr. H. G. Belschner, and arrangements made to undertake further investigations at a later date.

(vi) *Passiflora alba* (*"Wild Passion Vine"*).—This plant has been found to be toxic by Dodd, but as certain feeding tests at Glenfield had failed to confirm its toxicity, additional feeding tests have been undertaken. Though not yet concluded, we may state that these led to ill effects in a calf.

(vii) *Melia azederach* (*"White Cedar"*).—A feeding test showed this to be toxic, thus confirming the investigations made by Whitehouse.

(1) *Found to be toxic.*

(*a*) *Pimelea pauciflora.*—This has come under suspicion in connexion with two mortalities in stock and feeding tests have shown it to be poisonous. The work is not yet completed.

(*b*) *Nicotiana glauca* (*"Tree Tobacco"*).—This plant has often come under suspicion, but no feeding experiments have been recorded. Tests show it to be toxic at least for sheep.

(2) *Not found to be toxic.*

(*a*) *Solanum pseudo-capsicum.*—Leaves only tested. Apparently harmless for sheep.

(*b*) *Amsinckia intermedia* (*"Yellow Burr Weed"*).—Tested on sheep. Not toxic.

(*c*) *Euphorbia eremophila.*—Very distasteful to stock. Not found to be toxic for sheep

(*d*) *Trichinum semilanatum.*—Not found to be toxic for sheep.

(*e*) *Solanum triflorum.*—Berries not toxic for sheep.

(*f*) *Breynia oblongifolia.*—Tested on sheep and cattle. Not toxic.

(*g*) *Chenopodium carinatum.*—Not toxic for sheep.

(*h*) *Boussingaultia baselloides* (*"Lambs Tails"*).—A statement appeared in the daily press to the effect that this vine had poisoned some people in Queensland. It was tested on cattle, sheep, and pigs, but caused no ill effects. Soaked in water the plant quickly decomposes, and renders water unsuitable for drinking purposes, but such water did not poison stock.

(*i*) *Lantana camara* (*"Lantana"*).—A re-test of this plant confirmed our previous finding, viz., that it is not toxic.

(3) *Tests not yet completed.*

(*a*) *Castanospermum australe* (*"Black Bean"*).—Although reputed to cause gastro-enteritis in stock tests of the seeds on cattle failed to confirm it as a toxic plant. The tests will have to be continued, as in view of the clinical evidence we do not consider them definite.

(*b*) *Xanthorrhoea australe* (*"Green tree"*).—Feeding tests in progress.

Publications.

H. R. Seddon and H. C. White, "*Acacia glaucescens* proved poisonous to stock." *Agric. Gaz., N.S.W.*, **39**, 1928, p. 668.

H. R. Seddon and H. C. White, "*Euphorbia Drummondii* proved poisonous to stock." *Agric. Gaz., N.S.W.*, **39**, 1928.

H. R. Seddon and W. L. Hindmarsh, "*Boussingaultia baselloides* —a reputed poisonous vine." *Agric. Gas., N.S.W.*, **39**, 1928

4. Isolation and Classification of Active Principles.

(i) *Cyanogenetic Plants.*

Following the observation of Dr. Seddon upon the fatal effects on sheep of the sally wattle, *Acacia glaucescens*, it was found that this plant generates prussic acid, not as most of such plants do, when merely bruised, but owing to the deficiency of the necessary ferment only when this ferment is supplied from other sources or during the digestive processes in the animal. The cyanogenetic glucoside has been isolated, and has been found to be identical with sambunigrin, first found in the black elder of Europe—*Sambucus nigra.*

Three other species of acacia have been shown to be cyanogenetic —*Acacia Cheelii*, which contains the same poisonous glucoside as the above. *Acacia Cunninghamii*, formerly thought to be toxic by reason of its "saponin" like constituents, has now also been proved cyanogenetic. From this and *Acacia doratoxylon* the poisonous ingredient has not yet been isolated. Some 85 species of acacia have been examined, and it has been decided by the Committee to make a complete survey of the *Acacias*, but the material could not be collected this year.

Goodia lotifolia (*the clover tree*).—Although no recent cases of poisoning have occurred with this plant, about 25 years ago it was strongly suspected to be toxic, and incidentally as strongly defended as a harmless and indeed valuable fodder. Experiment has shown

that it is strongly cyanogenetic. In fact, it yields a larger amount of prussic acid than any other Australian plant except *Heterodendron*. In connexion with this plant it is of interest to observe that although all the eight fresh specimens obtained from such widely separated localities as North Queensland, Kangaroo Island, Middle Harbour, Sydney, Botanic Gardens, Melbourne and Sydney, were cyanogenetic, yet 22 Herbarium specimens when tested seemed to be entirely free from prussic acid. Presumably the glucoside disappears on keeping. This emphasises the importance of continued and systematic examination.

Euphorbia Drummondii.—This plant has long been suspected as having poisonous properties, although in many cases it is apparently quite innocuous. A systematic collection and examination on a limited scale was decided upon, and it was found that specimens from Brewarrina yielded hydrocyanic acid in amount sufficient to render the plant dangerous to sheep. Specimens from Dubbo and Merriwa have been found poisonous, but the amount has not been determined. One hundred and thirty-eight specimens have been examined, of which fourteen were positive. An account of experiments with *Euphorbia Drummondii* carried out at Glenfield is given in the C.S.I.R. Journal, Vol. 1, No. 5, August, 1928, p. 268.

Variegated thistle—Silybum mariana.—The symptoms of poisoning by this plant have pointed to its containing hydrocyanic acid, but 22 specimens collected as widely as possible have so far failed to confirm this suspicion. Transplanted samples have also been tested with negative result, and no definite positive results have yet been obtained. Feeding experiments and pharmacological experiments have likewise yet thrown no light on the matter.

Among other plants shown to be cyanogenetic are *Halorrhagis* (six specimens) and *Poranthera microphylla* (five specimens), and (to a very slight extent) *P. corymbosa*. It is considered that although *P. microphylla* is cyanogenetic, it is hardly likely to be dangerous to stock, for it is scattered in distribution, small in habit, and no animal is likely to be able to gather under ordinary circumstances sufficient to produce a fatal effect. Herbarium specimens (13) of this plant have given a negative result.

Eucalyptus corynocalyx (*the sugar gum tree*).—This tree, being practically free from oil has been fed to cattle in times of drought. The fatal results can now be attributed to prussic acid—one specimen from South Australia contained 0.18 per cent., and all Herbarium specimens were positive.

General.—It was previously known, chiefly from the work of the late Dr. Petrie and others, that there were many cyanogenetic plants among the native flora of Australia, and in continuation of the work, some 600 specimens have been examined during the year for prussic acid, chiefly by Mr. C. B. Cox. It was felt that not only should qualitative tests be made, but that quantitative experiments were also necessary, and estimations have been made to ascertain both the amount and the seasonal variations of this acid.

The experiments on cyanogenetic plants has rendered necessary a critical revision of our knowledge of the toxicity of prussic acid

on animals. Experiments have been initiated upon the conditions under which animals are able to decompose such glucosides as are found in these plants.

Other work has included preliminary experiments on *Isotropis atropurpurea*, *Xanthium strumarium*, *Solanum cinereum*, *Stachys arvensis*, and *Sorghums*.

Lotus australis.—Seven positive specimens and 161 negative and two positive specimens of *Indigofera australis* have been examined.

(ii) *Publications*.—The presence of cyanogenetic glucosides in certain species of Acacia—Finnemore and Glenhill, *Australian Journal of Pharmacy*, 1928.

Cyanogenetic glucosides in Australian Plants—Finnemore and Cox. *Journal of the Royal Society of N.S.W.*, 1928, in press.

5. Chemical Study of Active Principles.

Saponins.

The presence of an unknown poisonous principle in a plant often coincides with the property of producing a frothing extract with water. In some cases, this frothing property is very marked, and it may then be possible to isolate a solid substance which will redissolve in water to give a frothing solution. Such a substance is usually classified as a saponin. In spite of a great deal of work on the subject, the chemistry of the saponins cannot be regarded as being in a satisfactory state. In the vast majority of cases, so-called saponins have never been proved to consist of a single chemical compound. In addition, chemical analyses almost invariably show the presence of inorganic materials, which may be, as in the case of the gums, essential constituents, or on the other hand, merely impurities.

In the investigation being made at present by Mr. A. A. Luciano in the Department of Organic Chemistry, a technique is being developed by which saponin-containing substance may be treated in a simple way so as to remove the saponin, with or without associated materials. This must be followed, necessarily, by a separation of the saponin from the other substances with which it is mixed. It is hoped in this way to supersede the existing processes for saponin extraction, none of which can be regarded as entirely satisfactory as a general exploratory method. One has now been devised which shows considerable promise, and it is being tested exhaustively on the well known saponin-containing material, *Quillaia* bark. The aim cannot, however, be considered as fully achieved until fractionation of the product into chemically dissimilar constituents is no longer possible. This stage has not been reached up to the present.

6. Pharmacological Experiments.

The work in this section has included preliminary experiments on the action on animals of extracts prepared in attempts to isolate active principles of *Isotropis atropurpurea*, *Quillaia*, and other plants. The extraction of the active principle of *Hypericum perforatum* is also being studied.

Notes on Certain Disorders of Cleopatra Apples.

W. M. Carne, H. A. Pittman, and H. G. Elliott.

During the course of storage experiments in the studies on bitter pit, to be published elsewhere,* it was noted that Cleopatra apples were very subject to three disorders which appear to be related to the particular type of growth characteristic of the variety.

They are "woolly stripe," "hollow core," and "mouldy core."

(*a*) *Woolly Stripe* (Wollstreifen).—This is a condition of the carpels "in which the inner walls of the core divisions are not uniformly smooth and solid, but show a surface crossed by streaks which look white and woolly, and extend slantingly from the centre to the outside." (2) The white woolly appearance is due to loose, filamentous, cellular tissue protruding through ruptures in the carpellary walls.

This condition appeared to be almost normal in the fruits examined. Of 3,135 apples in the storage tests, only two apples were found without woolly stripe. In the later stages of maturity, the stripes become distinctly brown. From one to many stripes were found on each carpellary wall. Woolly stripe is undoubtedly a growth phenomenon.

(*b*) *Hollow Core.*—This condition occurred to some degree in the majority of the apples approaching full size. It also is a growth phenomenon, and results from the separation of the carpels to form an opening in the centre of the fruit which may extend into the calyx tube. The "undescribed core disease" mentioned by Smith (1) (Fig. 1) appears to be a further development resulting in the rupture extending through the carpels into the flesh, usually at the calyx end of the carpellary chamber (Fig. 1). The affected tissue turns brown around the point of rupture and rot fungi may enter the flesh.

Apples showing large hollow cores and rupturing of the flesh can frequently be recognized by an irregularity of growth at the calyx end (Fig. 2).

(*c*) *Mouldy Core.*—The liability of Cleopatra apples to mouldy core is well known. Starting from the core region rot spreads through the fruit, sometimes coming to the surface before the fruit is generally involved, but frequently working out fairly regularly from the centre until the apple consists of rotted tissues surrounded by a thin layer of sound flesh (Fig. 3). Such apples respond to pressure by the fingers like an apple with internal breakdown. The apples with irregular growth at the calyx end mentioned under hollow core are very liable to mouldy core and are discarded by careful growers when packing.

(*d*) *General Considerations.*—There is little doubt that woolly stripe, hollow core, and mouldy core are closely related in that they are the result of irregular and rapid growth. In a variety such as Cleopatra, which increases in size very rapidly when maturing, the strains set up in the older tissues by the growth of the newer result

* Commonwealth Council for Scientific and Industrial Research, Bulletin No. 41, 1929.

in ruptures. These produce woolly stripe and hollow core. In cases where marked irregularity of growth occurs, the stresses which cause hollow core may result in the rupturing of the flesh. These breaks in the flesh appear to occur most commonly at the base of the calyx tube. The calyx tube of the Cleopatra is normally relatively wide and open, allowing the ingress of spores. The ruptures in the carpellary walls, and in the flesh of the apple, allow rot fungi to become established, and mouldy core sets in.

As shown in Table 1, flesh rupture following hollow core occurred in 22.7 per cent. of the apples in open store, ranging from 18.5 per cent. in apples under 6.3 cm. diam. to 36.2 per cent. in apples over 7 cm. diam. In cold store, the figures were 2.35 per cent., 18.4 per cent., and 37.9 per cent. respectively, indicating that the trouble was developed on the trees, and was not affected by the method of storage.

Fungal growth inside the carpels but not extending to the flesh occurred in 53.9 per cent. of all apples in open store, ranging from 44.3 per cent. in apples under 6.3 cm. diam. to 67.6 per cent. in those over 7.0 cm. diam. The corresponding figures for apples in cold storage were 32.4 per cent., 28.5 per cent., and 33.8 per cent. (see Table 2). The difference between the figures for open stored and cold stored fruit was probably due to the inhibiting effect of cold storage on fungal growth.

Mouldy core (fungal growth attacking the flesh around the core) occurred to the extent of 2.32 per cent. in the open stored fruit ranging from 2.1 per cent. in those under 6.3 cm. diam. to 3.3 in fruit over 7 cm. diam. In the fruit that had been cold stored the figures were 5.4 per cent., 4.3 per cent., and 8.0 per cent. respectively (see Table 14). No explanation as to the difference between cold stored and open stored fruit in respect to mouldy core is offered.

Examination of mouldy core tissue has shown the presence of—

Alternaria sp.
Oospora sp.
Penicillium spp.
Bacteria.

Examination of the brown flesh rupture following hollow core (Smith's "undescribed core disease") gave the following:—

Penicillium spp.
Cladosporium sp.
Acrostalagmus sp.
Gloeosporium sp.
Bacteria.

This disorder was evidently responsible for a proportion of the mouldy core.

Literature Cited.

1. Smith, A. J.—Brown Heart in Australian Apple Shipments. British Department of Scientific and Industrial Research Food Investigation Board Special Report 22, London, 1925.

2. Sorauer, P.—Manual of Plant Diseases. Non-Parasitic Diseases, 3rd Ed. Translation by F. Dorrance, Vol. 1, Part IV., p. 324. Record Press., Pa. U.S.A., 1915.

TABLE 1.

FLESH RUPTURE FOLLOWING HOLLOW CORE.

Size.	Date Picked.	Open Store.			Cold Store.			Cold Store (Wrapped).		
		Date Cut.	Number Apples.	Percentage Affected.	Date Cut.	Number Apples.	Percentage Affected.	Date Cut.	Number Apples.	Percentage Affected.
Under 6·3 cm. or 2½ inches ..	6.2.28	19.3.28	105	28.6	30.4.28	105	11·4	..	..	..
	13.2.28	26.3.28	156	24.3	8.5.28	169	10·6	..	..	..
	20.2.28	2.4.28	40	12.5	14.5.28	156	26·9	..	..	..
	27.2.28	11.4.28	80	6.2	21.5.28	83	15·7	..	..	..
	5.3.28	17.4.28	89	10.1	28.5.28	159	22·6	..	..	..
	12.3.28	23.4.28	..	..	5.6.28	75	22·7	..	..	..
Mean ..	..	..	..	18.5	..	..	18·4	..	..	..
6·3–7·0 cm. or 2½ 2¾ inches ..	6.2.28	19.3.28	85	30.6	30.4.28	183	18·2	30.4.28	88	25·0
	12.2.28	26.3.28	53	24.5	8.5.28	50	24·0	8.5.28	96	20·8
	20.2.28	2.4.28	103	26.2	14.5.28	51	45·1	14.5.28	99	39·4
	27.2.28	11.4.28	99	12.1	21.5.28	100	30·0	..	..	..
	5.3.28	17.4.28	116	14.7	28.5.28	100	29·0	..	..	..
	12.3.28	23.4.28	100	26.0	5.6.28	112	23·2	..	..	..
Mean ..	..	..	..	21.7	..	..	26·0	..	..	28.6
Over 7·0 cm. or over 2¾ inches ..	6.2.28	..	..	..	..	..	..	..	..	..
	12.2.28	26.3.28	35	48.6	8.5.28	35	34·3	..	..	..
	20.2.28	2.4.28	44	47.7	14.5.28	40	62·5	..	..	..
	27.2.28	11.4.28	38	21.0	21.5.28	41	39·0	..	..	..
	5.3.28	17.4.28	25	40.0	28.5.28	41	43·9	..	..	..
	12.3.28	23.4.28	40	25·0	5.6.28	80	23·8	..	..	..
Mean ..	..	..	..	36·2	..	..	37·9	..	..	..
Over 7·6 cm. or over 3 inches ..	12.3.28	..	..	..	5.6.28	64	21·8	..	..	..
Mean ..	..	..	..	..	..	..	21·8	..	..	..
TOTAL ..	..	..	1,208	22·7	..	1,644	23·5	..	283	28·6

All sizes 3,135 apples, 742 affected = 23·7 per cent.

TABLE 2.

CLEOPATRA APPLES WITH FUNGAL GROWTH IN CORE AND MOULDY CORE.

Size.	Date Picked.	Open Store.				Cold Store.				Cold Store (Wrapped).			
		Date Cut.	Number Apples.	Percentage Affected Fungal Growth.	Percentage Affected Mouldy Core.	Date Cut.	Number Apples.	Percentage Affected Fungal Growth.	Percentage Affected Mouldy Core.	Date Cut.	Number Apples.	Percentage Affected Fungal Growth.	Percentage Affected Mouldy Core.
Under 6·3 cm. or 2½ inches	6.2.28	19.3.28	105	40·0	3·8	30.4.28	105	22·8	2·8	..	..	..	..
	13.2.28	26.3.28	156	45·5	1·9	8.5.28	169	19·5	5·3	..	..	..	..
	20.2.28	2.4.28	40	35·0	5·0	14.5.28	156	28·8	2·6	..	..	..	..
	27.2.28	11.4.28	80	45·0	..	21.5.28	83	36·1	6·0	..	..	..	..
	5.3.28	17.4.28	89	50·5	1·1	28.5.28	159	32·0	5·0	..	..	..	..
	12.3.28	..	..	..	..	5.6.28	75	40·0	6·7	..	..	..	..
Mean ..	..	..	..	44·3	2·1	..	..	28·5	4·3	..	..	..	..
6·3 7·0 cm. or 2½–2¾ inches	6.2.28	19.3.28	85	68·2	1·2	30.4.28	183	24·6	4·9	30.4.28	89	16·8	2·2
	13.2.28	26.3.28	53	56·6	3·8	8.5.28	50	34·0	4·0	8.5.28	96	35·4	5·2
	20.2.28	2.4.28	103	57·3	·9	14.5.28	51	50·9	9·8	14.5.28	99	41.4	4.0
	27.2.28	11.4.28	99	63·5	1·0	21.5.28	100	47·0	8·0	..	..	..	..
	5.3.28	17.4.28	116	45·7	3·4	28.5.28	100	40·0	2·0	..	..	..	..
	12.3.28	23.4.28	100	55·0	3·0	5.6.28	112	26·8	5·4	..	..	..	..
Mean ..	..	..	..	57·4	2·1	..	..	34·4	5·4	..	..	31·8	4·2
Over 7·0 cm. or over 2¾ inches	6.2.28	..	..	..	..	..	..	..	..	..	..	..	..
	12.2.28	26.3.28	35	80·0	..	8.5.28	35	51·4	17·1	..	..	..	..
	20.2.28	2.4.28	44	63·6	2·3	14.5.28	40	60·0	7·5	..	..	..	..
	27.2.28	11.4.28	38	71·0	..	21.5.28	41	48·8	4·9	..	..	..	..
	5.3.28	17.4.28	25	72·0	8·0	28.5.28	41	39·0	4·9	..	..	..	..
	12.3.28	23.4.28	40	55·0	7.5	5.6.28	80	23·7	12·5	..	..	..	..
Mean ..	..	..	..	67·6	3·3	..	..	33·8	8·0	..	..	..	..
Over 7·5 cm. (3 inches and over)	12.3.28	..	..	..	..	5.6.28	64	28·1	4·7	..	..	..	..
Mean ..	..	..	..	..	..	..	..	28·1	4·7	..	..	..	..
TOTAL ..	..	..	1,208	53·9	2·3	..	1,644	32·4	5·4	..	283	31·8	4·2

All sizes 3,135 apples, 1,272 with fungal growth in core = 40·5 per cent. All sizes 3,135 apples, 129 with mouldy core = 4·1 per cent.

Boussingaultia Baselloides, "Lambs' Tails," a Reputed Poisonous Climber.

H. R. Seddon, D.V.Sc., and W. L. Hindmarsh, B.V.Sc., M.R.C.V.S., D.V.H.

(*A research undertaken under the Poison Plants Committee of the Council for Scientific and Industrial Research.*)

Our attention was first called to this plant by the appearance of a news item in the daily press in which it was alleged that persons had been poisoned by drinking water in which the branches of this climber had been soaking. The plant in question is a luxuriant climber which is grown at times over tanks and outhouses, and it would thus be an easy matter for the pendulous branches to hang down on the inside of an open tank over which it was trailing.

The somewhat startling news caption therefore interested us, as it is possible that stock might gain ready access to the plant, and as there appeared to be no definite information as to its toxicity, it was deemed advisable to test it at the earliest opportunity.

Material Used.—Supplies of the plant from two sources were tested. The first was obtained by the courtesy of Mr. H. Finnemore, of the Pharmacy Department of the University of Sydney, the second from plants growing at Liverpool (comparatively close to the Glenfield Veterinary Research Station), was drawn upon more largely, as we were thereby assured of ample supplies of the freshly gathered plant.

The identity of the plant used was kindly confirmed by the Director, Botanic Gardens, Sydney.

Experiments with Cattle.

1. A steer, two and a half years old, was offered 12 lb. of the creeper (in the flowering stage), but none was eaten. On the day following the plant was cut up and mixed with chaff. During the day 21 lb. of the plant was eaten.

Result.—No ill effects were noted.

2. A steer, three years of age, was offered 8 lb. of the plant (in the flowering and early seeding stage, freshly cut), and ate 2 lb. Later in the same day it ate 8 lb. mixed with chaff. During the seven succeeding days it ate the plant readily, at first with a little chaff, but during the last four days the creeper was the sole article of diet. During this period of eight days 280 lb. of the plant was eaten.

Result.—No ill effects were noted.

Experiments with Sheep.

1. Four pounds of the freshly cut plant (in flower and early seed) was soaked in 1 gallon of water for three hours, and a seven-year-old sheep was drenched with 1 pint of the fluid. No ill effects were apparent during the succeeding 24 hours, but the sheep was permitted to drink only water in which the plant was soaking (4 lb. of plant to each gallon of water). As the sheep readily drank this water, the procedure was followed for six days.

N.B.—The plant was rapidly decomposed in the water, and fresh supplies were placed in the trough each morning, the plant being allowed to steep during the subsequent 24 hours.

Result.—No ill effects were noted.

2. Four pounds of the freshly cut plant (in the flowering and early seeding stage) were minced and steeped in 4 pints of water for 24 hours. The fluid was then pressed out, and 2½ pints of the expressed liquid was given to a two-year-old sheep as a drench at about 11 a.m. in the morning.

Result.—During the afternoon the sheep passed some rather liquid faeces. Otherwise the animal remained normal.

Experiments with Pigs.

1. Two pounds of the freshly cut plant (in flower) was minced, mixed with milk and offered to a pig. The pig refused to eat it until the following afternoon, when, on the addition of some pollard, it was consumed. On the succeeding day 2 lb. of the plant, mixed with pollard, was again eaten.

Result.—No ill effects were noted.

2. Four pounds of the freshly cut plant (in the flowering and early seeding stage) was steeped in water for three hours. A pig, 79 lb. in weight, was drenched with 1 pint of the fluid. No ill effects being noted as a result, 4 lb. of the plant was steeped in water over night; and the fluid decanted. This fluid was then mixed with pollard and fed to the same pig. This procedure was continued for six successive days.

Result.—The pig showed slight diarrhoea on the fifth day, but was normal again on the sixth day. No other ill effects were noted.

Conclusions.

1. To cattle not accustomed to the plant, it may at first be distasteful.

2. The only ill effect produced in these experiments has been a transient looseness of the bowels in a sheep and a pig. In the pig this occurred after five days of giving, with the food, water in which the plant had been steeped. In the sheep it occurred after drenching with an aqueous extract of the plant.

3. Whilst the above may be taken as showing conclusively that the plant is not to be regarded as poisonous, the fact that, when soaked in water it leads to the water becoming very slimy, and of such a nature as to become unpalatable and offensive to drink, places the plant in a category which renders it an undesirable one to grow in a situation where it may foul the water supply.

PLATE 1.

Fig. 1.—Woolly Stripe, Hollow Core, and Smith's "Core Disease" on Cleopatra Apples.

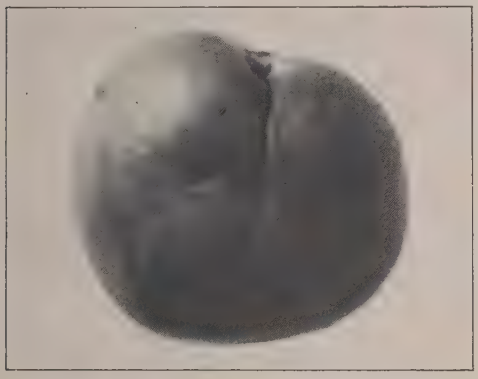


Fig. 2.—Malformed Cleopatra Apple. Such apples are usually affected with Mouldy Core.

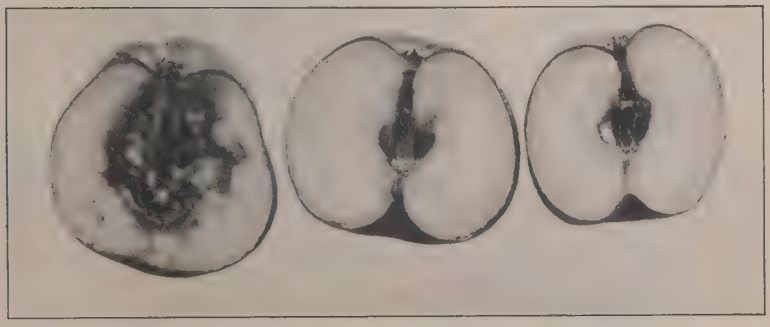
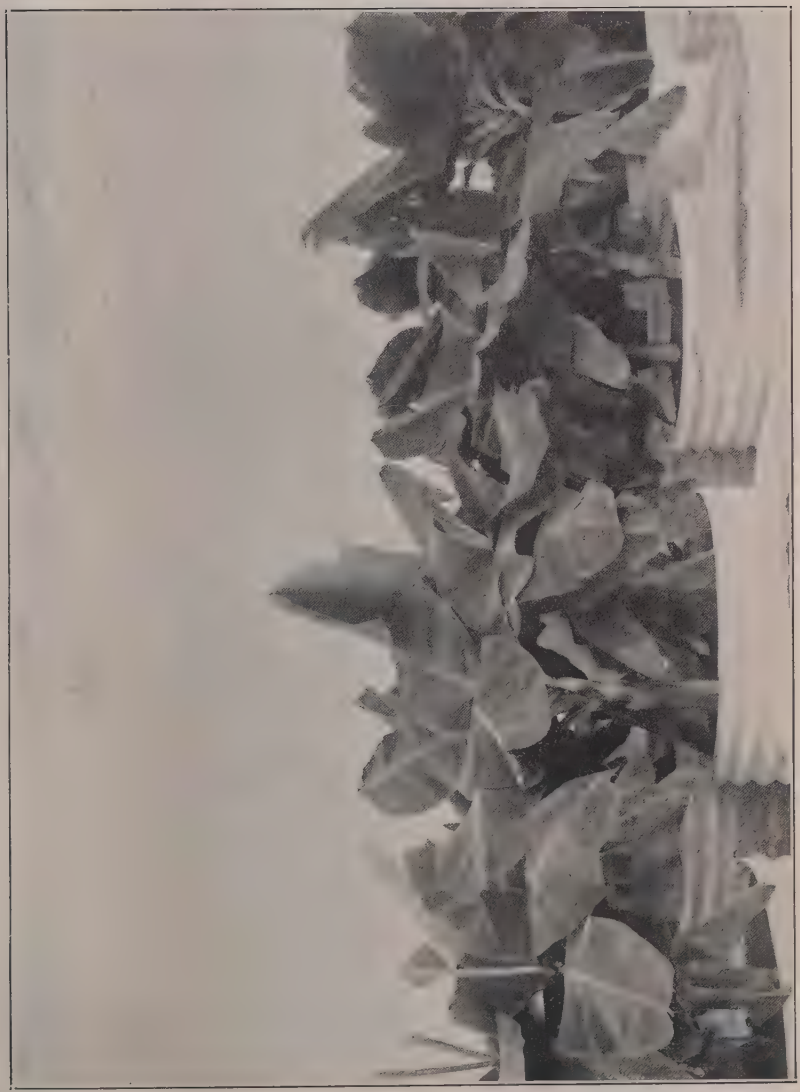


Fig. 3.—"Mouldy Core" (left), fungal growth in the core (centre and right), on Cleopatra Apples.

PLATE 2.

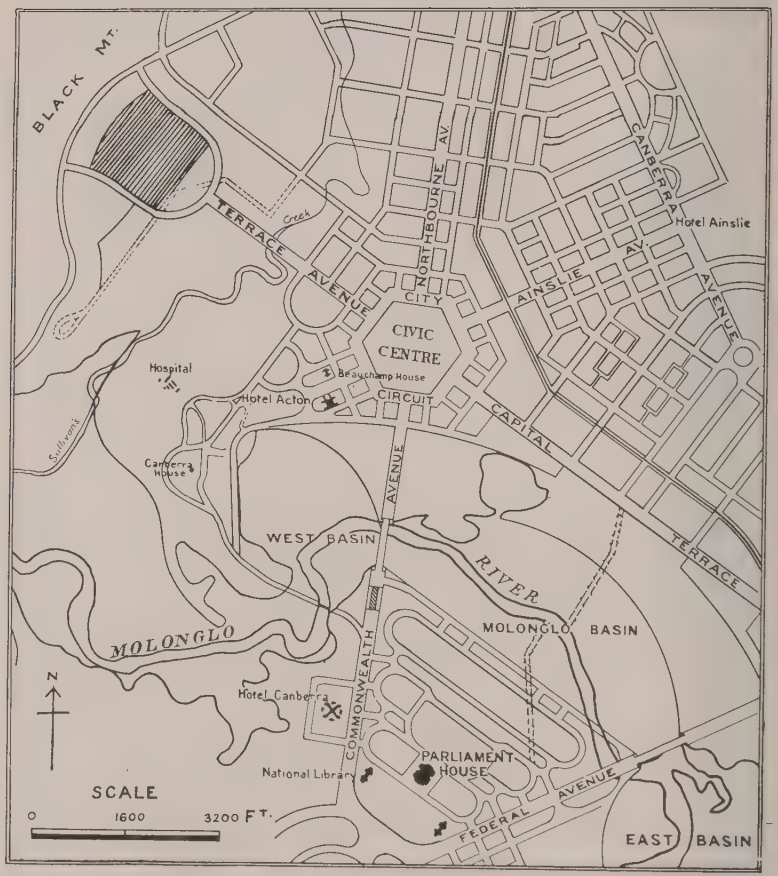
Young Banana Plants affected with Bunchy Top.

PLATE 3.



Young Healthy Banana Plants.

PLATE 4.



SITE FOR COUNCIL'S LABORATORIES AT CANBERRA.

(The area is hatched in the above sketch plan.)

NOTES.

Area at Canberra for Council's Laboratories.

An area of over 50 acres has recently been set aside at Canberra as a site for the establishment of experimental field plots, &c., and for the erection of the various buildings and laboratories that will ultimately be necessary for the Council's operations. This area is conveniently located at the foot of Black Mountain, and is at the north-west end of University (Terrace) Avenue. The buildings of the Council will thus look down that Avenue, and will face the buildings on City Hill (Civic Centre) at its other end about a mile away. The exact location of the site is given in the illustration (Plate 4). It is almost contiguous with the area set aside for University purposes. The latter area is to the south-west of University (Terrace) Avenue.

It is proposed to erect central laboratories for the Divisions of Economic Entomology and Economic Botany on the Council's site almost immediately. Two insectaries for the former Division are now in course of erection, and plans for its laboratories have been completed. Plans for the laboratories of the Division of Economic Botany are still under consideration.

Return of Mr. G. Lightfoot.

The Secretary of the Council—Mr. G. Lightfoot—who for the last eight months has been spending his long-service leave in Great Britain and Europe, where he has also taken the opportunity of visiting various research centres, has now left the Continent. He is expected to reach Melbourne on his return on the 21st February.

Catalogue of Scientific Periodicals.

The catalogue of scientific and technical periodicals in the libraries of the Commonwealth, mention of which was made on page 319 of the first volume of this Journal, is now practically complete in typescript form. Mr. E. R. Pitt, B.A., the general editor, who has for the last eleven months devoted his entire time to this work, has now returned to his normal duties at the Melbourne Public Library.

For the purpose of making the Australian section as complete as possible, a questionnaire was sent out to all libraries and publishing institutions of the Commonwealth. An immense amount of material was received in reply, and, on classifying this, it was found to yield very complete information as to all Australian publications.

In order to make sure of the correctness of the entries, one or two of the more intricate sections involving the international entries are being typed in advance, and sent back to the State committees for their checking before final inclusion in the catalogue.

As it was desired that entries should be complete up to the time of going to press, a list was prepared of all new periodicals which had

commenced publication during the preparation period of the catalogue. This was circularized to all the libraries concerned, and the entries included in the final manuscript. It can, therefore, be considered that the catalogue in its final form will be complete up to the end of 1928.

Citrus Preservation Experiments: The Necessity for the Careful Handling of Citrus Fruit.

In a previous issue (Vol. 1, p. 307), an account was given of the objects of the co-operative work on the preservation of citrus fruits being carried out under the direction of the Citrus Preservation Committee. Some results of the investigations are now available, and are reported on in the paragraphs that follow.

Experiments this year have been confined to investigating the effects of preliminary washing with various solutions such as borax, sodium bicarbonate, &c. and of coating with a film of wax. The investigation also included the influence of the handling of the fruit in the grove and the packing houses, on the susceptibility to mould infection. In addition, a study of the moulds themselves, and the action of the various treatments on them, has been undertaken. The main portion of the work is still incomplete, but definite results have been obtained as regards the handling of the fruit, and it has been thought advisable to publish these at once.

The fruit consisted of Navel oranges picked at the end of August from five groves in all, of which two were at Mildura, two were at Irymple, and one was at Curlwaa. Half of the fruit from each grove was clipped from the tree with blunt-pointed clippers, and was handled with gloves during picking and packing, whilst the other half was pulled from the tree in the ordinary manner, and handled through all stages without gloves. The oranges were packed without wrapping and railed to the Government Cool Stores at Victoria Dock, Melbourne, where the treatment and storage took place.

Each experiment embraced a batch of fruit from each grove, and in every case half of each batch was carefully handled. The treated fruit was processed by means of a small commercial plant supplied by the Lightning Fruit Grader Company and consisted of immersion tanks, mechanical brushes, a drier and a grader. After treatment the fruit was wrapped in sulphite paper and packed in Canadian cases, and stored at 38° F.

Although the mycological examination of the atmosphere in grove packing sheds, trucks, and cool store showed that the fruit was exposed to possible infection of numerous moulds, only two appear to be capable of infecting citrus fruit, namely, the "blue mould" *Penicillium italicum*, and the "green mould" *Penicillium digitatum*. The former is the chief mould affecting oranges in cool store, whilst the latter is mainly of importance at ordinary temperatures.

The incidence of *P. digitatum* was comparatively small, and the number of oranges so infected was found to have increased only very slightly even after several weeks' storage. Thus, in an inspection made on 8th November, only 1.2 per cent. of the fruit was infected with this

mould, which had increased to 3 per cent. by 17th December, whilst *P. italicum* was found infecting 20 and 70 per cent. in the November and the December counts respectively.

The following table shows the percentages of oranges infected with both moulds at different times, and indicates the advantage of careful handling. The fruit was put in cool storage between 15th September and 6th October.

Percentages of Stored Oranges Affected with P. italicum and P. digitatum.

—	Carefully Handled.	Ordinarily Handled.
28th October ..	7·8	10·5
8th November ..	17·4	24·6
17th December ..	67	76·2

In the November and December inspections, the position of the moulds on the fruit was noted, and the following table gives figures representing the percentages of infections with *P. italicum* on the skin near the stem, in the medial part, and round the navel.

Percentages of Stored Oranges Affected with P. italicum.

—	Stem.	Navel.	Medial
8th November, carefully handled ..	7·4	2·2	6·7
„ ordinarily handled ..	15·0	2·0	6·2
17th December, carefully handled ..	15·4	14·3	43
„ ordinarily handled ..	28·4	12·5	42

These figures show that the advantage of carefully handling fruit is due to there being less mould round the stem, that is the portion which is liable to receive injury when the fruit is pulled from the tree. The figures therefore emphasize the necessity of clipping the oranges, and the use of clippers in picking the fruit.

One of the most serious troubles with oranges during storage is the development of browning of the skin. The skin becomes covered with brown patches varying in size, and although this may not affect the inside, it seriously detracts from the appearance. The percentages of oranges showing browning were therefore also counted, and the figures are shown in the table below.

Percentages of Stored Oranges showing Browning.

—	6th October.	8th November.
Carefully handled	17·5	26·1
Ordinarily handled	31·9	35·6

These figures also show a very decided advantage in favour of careful handling.

In the fruit, on arrival in Melbourne, considerable bruising was observed, due to the packing which has to be reasonably tight for transport. As this may be a cause of loss, the question of the best means of transporting oranges intended for local use is receiving attention in future experiments.

The Flying Fox Problem—Mr. F. N. Ratcliffe.

In a previous issue of the Journal (Volume 1, No. 5, p. 314) reference was made to a co-operative arrangement reached by the New South Wales and Queensland Departments of Agriculture and the Council to make a systematic and biological study of those species of flying fox which are a pest in Australia. The position of a biologist to carry out the work has now been filled by the appointment of Mr. F N. Ratcliffe, who was formerly an officer of the Empire Marketing Board. The appointee is a graduate of the University of Oxford, with first class honours in zoology, where he was under Professor Julian Huxley. Subsequent to completing his course at Oxford he visited Princetown, U.S.A., as a Proctor Travelling Fellow, and attended graduate courses in various zoological subjects.

Mr. Ratcliffe left London per the s.s. *Largs Bay,* and is expected to reach Melbourne on about 28th February.

Meetings of the Full Council.

The meetings comprising the 6th session of the full Council (for Scientific and Industrial Research) were held in Melbourne on the 12th, 13th, and 14th December last. The more important matters discussed were as follows:—

Address by the Minister (Senator the Right Honorable Sir George Pearce).

At an early stage of the meeting, the Minister (the Right Honorable Sir George Pearce) was present, and on behalf of the Government thanked the individual members of the Council for the work the latter had already carried out. He indicated that the Government was in accord with the general movement for the greater application of science to industry, and approved of the lines along which the Council was working. He then referred at some length to the Government's ideas in proposing that some work on economic research should be carried out. It was essential in connexion with legislation and administration, particularly where such functions affect production, that those who direct these activities should have available economic facts scientifically ascertained and determined by examination and analysis of properly collected statistical data. The Parliament, Government, or authority taking action might then do so, fully informed as to the economic effect of its action. It was also of great importance that public opinion, which ultimately decided politics, should be armed with correct information and scientifically ascertained facts to enable it to arrive at wise determinations.

Animal Diseases.—A report was presented to the Council on the present stage of the following investigations:—Kimberley horse disease, braxy and braxy-like diseases, tuberculosis in stock, pleuro-pneumonia in cattle, paralysis in pigs.

Botanical Investigations.—Dr. B. T. Dickson's memorandum on this matter, which had previously been discussed by the Standing Committee on Agriculture, was approved in general.

Grassland Problems.—Professor A. E. V. Richardson's memorandum on this matter (see p. 5) was considered. The desirability of the Council developing a programme of research along the lines of the memorandum was affirmed.

Animal Problems—Report by Sir Arnold Theiler.—The comprehensive scheme of animal health research contained in the report of Sir Arnold Theiler was endorsed in general, it being recognized that it would be necessary to proceed slowly at first, and that it would be impossible to give full effect to the proposals for many years.

Division of Animal Nutrition—Report by Chief.—The Chief of the Division of Animal Nutrition (Professor Brailsford Robertson) submitted a comprehensive report on the work carried out by his division to date. Some progress has been made with the chemical work and two bulletins on the reports obtained to date are now in the press. The organization that the valuable co-operation of certain individual pastoralists has made it possible to devise for the various field stations of the division has proved to be very successful. At the present time some 1,200 sheep belonging to these pastoralists are being employed in the investigations. The husbandry of the sheep thus continues to be carried out with the highest practical skill by the owners or their employees.

Mineral Deficiencies of Pasture.—Professor A. E. V. Richardson reported that the co-operative work of mineral deficiencies in pastures which was being carried out at the Waite Institute, and in which work the Council and the Empire Marketing Board were co-operating, was proceeding satisfactorily. As regards the laboratory work, an intensive investigation was being made of the variation in composition of pasture plants—particularly as regards mineral nutrients—at various stages of growth, and when grown on different soils with different water supplies, and different conditions of soil, fertilization, &c. As regards field work, a considerable amount of time had been spent on the development of the necessary technique, and some interesting work had also been carried out on the degree of palatability of various pasture plants to sheep.

Division of Economic Entomology—Report by Chief.—The Chief of the Division of Economic Entomology (Dr. Tillyard) gave a brief report on the present position of the Division of Economic Entomology. Some delay had taken place owing to difficulties met with in the gathering together of the necessary personnel.

Buffalo Fly.—Special consideration was given to this problem, in view of its potential importance to Australia as a whole. The matter was considered as being urgent, and it was resolved that an immediate investigation of it should be made.

Division of Forest Products Research.—It was reported that the chief of this division (Mr. I. H. Boas) would return to Australia early in February, 1929. He would then prepare a scheme of his future programme and that scheme would be submitted to the Council later.

Other Matters.—Other matters to which consideration was given were as follows:—Cold storage research, dairy research, a programme of work for the Radio Research Board, the Commonwealth Scientific Publications Committee, and the Committee on the Maintenance of Standards.

Fourth Meeting of the Standing Committee on Agriculture.

The fourth meeting of the Standing Committee on Agriculture (see this Journal, Vol. 1, No. 1, p. 58) was held in Melbourne on the 10th and 11th December, 1928. Mr. G. L. Sutton, Director of the Western Australian Department of Agriculture, and Mr. E. Graham, Under-Secretary, Queensland Department of Agriculture and Stock, were unable to be present. The permanent heads of the other State Departments, however, attended. The Council was represented by Professor R. D. Watt and Dr. B. T. Dickson, in addition to the members of the Executive Committee. The more important matters discussed were as follows:—

Botanical Investigations in Australia.—Consideration was given to a memorandum prepared by Dr. B. T. Dickson on botanical investigations in general. The field of investigation was discussed in the report from five points of view:—(i) surveys of existing conditions; (ii) improvement possibilites; (iii) the introduction of plants which are desirable and suitable; (iv) the preservation of types studied; and (v) other problems, including studies in fungicides and nutrition, determinations, weed control, transportation and storage of agricultural products, plants and climate, problems in other industries, animal and human pathology, and a bureau of information. The meeting considered that the memorandum prepared by Dr. Dickson covered the field fully, and, further, that the programme should be carried out in co-operation with the States wherever possible. It was realized that it would be difficult to lay down any hard and fast rules as to the division of activities as between the Council and the States, but it was agreed that each individual case should be discussed on its merits as it arose.

Soils Investigations.—The present stage of the soil studies being carried out in the irrigation areas of the Murray and Murrumbidgee valleys, under the direction of Professor Prescott, was reported. It was considered that valuable work was being done, and that the present activities might well be extended on a co-operative basis with the States.

Entomological Activities of the Council.—The investigations proposed to be undertaken by the Division of Economic Entomology of the Council were briefly explained to the State representatives.

Problems of Animal Health—Report of Sir Arnold Theiler.—Consideration was given to the report furnished by Sir Arnold Theiler to the Council, largely from the point of view of how the work proposed by Sir Arnold would fit in with existing State activities. It was

realized that the proposals involved extensive and somewhat costly investigations covering a wide field, but in view of the importance of the industry concerned, the Committee was definitely of the opinion that the scheme should be put into operation. It was further of the view that State activities should not be in any way reduced, but, on the other hand, it was hoped that they would be stimulated by the introduction of the scheme.

Request for Extension Work by Council's Officers.—Some discussion took place as to the attitude the Council should adopt towards requests from individuals, growers' associations, &c., for its officers to carry out extension or educational work. It was agreed that the Council should make every endeavour to prevent its officers duplicating the extension work of State officers, in so far as that action was reasonably possible. It was realized that this decision could not safely be applied so strictly in those cases where Council officers were working in special fields of endeavour not covered by State extension officers, and where they had a special message to deliver.

Agrostological Work (and Plant Introduction Service).—Professor Richardson's memorandum on this matter (see p. 5) was discussed at some length. The proposal that some plant introduction work be carried out by the Council was approved in general, and it was agreed that such work should be carried out in collaboration with the States. It was also agreed that the Council would prepare a detailed scheme of work which it might appropriately undertake, and that it should submit this scheme to the next meeting of the Committee. As regards the various other points raised in the memorandum it was decided to discuss these in detail at the next meeting.

Dairy Research.—It was reported that at the present time Professor Wadham was inquiring into the conditions of the Australian dairying industry, but that he did not wish to make any statement prior to the completion of his inquiries. It was also reported that for various reasons no appointment had up to the present been made to the positions of dairy chemist and dairy bacteriologist, applications for which had been called some time previously.

Horticultural Work—Bud Selection.—Consideration was given to a proposal that had been made to bring an American expert in the comparatively recently developed methods of bud selection to Australia in order that he might give demonstrations, particularly as regards citrus fruit. The Committee was in general agreement that such a visit was desirable, although it was not perfectly decided as to whether that visit should be made immediately, or a year or so hence. Further consideration of an appropriate time was left to the Council.

Tobacco Investigations.—During the discussion of this item Mr. Gepp, Chairman of the Development and Migration Commission, and Mr. Slagg, Director of the Australia Tobacco Investigation, were present. Various suggestions aimed at the greater co-ordination of tobacco research, as carried out by the State Departments and by the Tobacco Investigation, were approved.

Uniformity of Plant Names throughout Australia.—Mention was made of the movement that had taken place recently in New South

Wales for the object of having uniform common names given throughout Australia to weeds, grasses, herbage plants, trees, and in fact the whole of the local flora. It was agreed that the Council should take the matter up through the Standing Committee on Agriculture in so far as agricultural matters were concerned.

Reports by Sir Arnold Theiler and Dr. J. B. Orr.

Sir Arnold Theiler and Dr. J. B. Orr have both furnished reports on their recent visits to Australia. It is proposed to publish both reports as one of the Council's pamphlet series. The publication is now in the press, and will be issued at an early date.

The Farnham Royal Entomological Laboratory or "Parasite Zoo."

In an earlier number of the Journal (Vol. 1, p. 127), an account was given of the establishment, at Farnham Royal, in Buckinghamshire, of a parasite laboratory or "zoo" for furthering the work of biological control of insect and weed pests. An account of the very successful first year's activities of this laboratory is now to hand. Beneficial parasites have been bred in vast numbers at the laboratory and transported overseas to the countries where the pests which they attack are rampant. Among the countries which have received consignments may be mentioned Australia, New Zealand, Canada, and South Africa.

The question of providing suitable conditions during transport is frequently one of the most difficult problems to be overcome. It is often found necessary to breed and export the injurious insect heavily infected with the required parasite. In England, the pine tortrix moth is kept in check by a parasite which feeds on the larval stage. During the year, between 20,000 and 30,000 of these larvae infected by the parasite were collected and sent to Ontario, where, although the pine tortrix moth flourishes, the parasite has hitherto been unknown. The greenhouse white fly, *Asterchiton vaporarium*, which attacks tomato plants in England, and which is also a serious pest in Ontario, is now being attacked by the progeny of 20,000 parasites which were imported from England by being kept in cold storage throughout the voyage.

In some cases it has been found that more than one parasite is available. Pear slugs to the number of 30,000, infected by three different parasites, have been sent to the Southern Hemisphere. Australia has also benefited by receiving consignments of a parasite which lays its eggs in the blowfly maggot, and eventually kills it. Supplies of the same parasite have also been sent to the Falkland Islands and to South Africa, where the blowfly is also a pest to the sheep owner.

Another use to which the laboratory is being put is to act as a half-way house in the transmission of insects from countries which are too far distant from each other for the insects to survive the voyage if it were made in one stage. As an example of this work, mention might be made of an attempt to introduce a parasite of the pink boll worm from the Sudan to Barbadoes, with Farnham Royal as a transmitting centre.

At the present time three Australian members of the staff of the Division of Economic Entomology of the Council for Scientific and Industrial Research are stationed at Farnham Royal, where they are assisting in the search for, and the breeding of, insects likely to be beneficial in the attack on certain Australian insect problems. These investigators are Mr. Holdaway, who is working on the blowfly problem, Mr. J. Evans, who is working on a codlin moth parasite, and Mr. S. Garthside, who is working on insects likely to be valuable in the possible biological control of weeds, particularly St. John's wort.

Recent and Forthcoming Publications of the Council.

Recent publications of the Council have been—

Bulletin No. 38.—"The Chemical Composition of Wool—with especial reference to the protein of wool fibre (keratin)," by Hedley R. Marston, Division of Animal Nutrition.

Bulletin No. 39.—"The Utilization of Sulphur by Animals—with especial reference to wool production," by Hedley R. Marston, Division of Animal Nutrition.

Pamphlet No. 9.—"A Forest Products Laboratory for Australia. Justification for its creation, outline of its organization, and rough estimate of cost," by A. J. Gibson, F.C.H., F.L.S., F.Z.S., Indian Forest Service.

Publications now in the press, and which will appear shortly, are—

Bulletin No. 40.—"Observations on the Hydatid Parasite (*Echinococcus granulosus*) and the control of hydatid disease in Australia," by I. Clunies Ross, D.V.Sc.

Bulletin No. 41.—"Studies concerning the so-called Bitter Pit of Apples in Australia, with special reference to the variety Cleopatra," by W. M. Carne, F.L.S., late Botanist and Plant Pathologist, Department of Agriculture, Western Australia, H. A. Pittman, B.Sc.Agr., Division of Economic Botany, C.S.I.R., and H. G. Elliot, Dip. Agr., Assistant Plant Pathologist, Department of Agriculture, Western Australia.

Pamphlet No. .—"The cattle tick pest and methods for its eradication," compiled by the Cattle Tick Dips Committee of the Council.

Pamphlet No. 10.—"The nutrition and health of animals"—Reports by Sir Arnold Theiler, K.C.M.G., D.Sc., and J. B. Orr, D.S.O., M.C., M.A., M.D,, D.Sc.

Pamphlet No. .—"The Tasmanian grass grub (*Oncopera intricata* Walker)—A preliminary report on its life history and methods of control," by Gerald F. Hill, Division of Economic Entomology.

Department of Scientific and Industrial Research, New Zealand—Bulletins.

Three further bulletins of the New Zealand Department of Scientific and Industrial Research have recently became available in Australia.

Bulletin No. 4 is a report on the Bergius process for the liquefaction of coal. The author, H. O. Askew, states in the introduction that the

bulletin is intended as a summary of the state of knowledge of the Bergius process up to the present time. He appends a six-page bibliography of papers and patents relating to the hydrogenation of coal and allied materials.

Bulletin No. 5, on plant-breeding methods and results, and written by F. W. Hilgendorf, M.A., D.Sc., gives an account of the success that has been achieved at Canterbury Agricultural College by cross breeding and selection in cereals, grasses and clovers, from the time it was first suggested up to the present day.

Bulletin No. 6 is again a summary of information compiled by H. O. Askew. It deals with all available information up to the end of 1927, on the Fischer process for the production of liquid fuels, and notably motor spirit, by the catalytic reduction of carbon monoxide. A wide interpretation has been given to the term Fischer process, so that instead of dealing merely with synthol formation, attention has been paid to the production of alcohols, acids, and the lower and higher hydrocarbons. As in the earlier bulletin on the Bergius process, a five-page bibliography is included.

The Science and Industry Endowment Fund—Recent Grants.

In two previous issues of the Journal (Vol. 1, No. 2, p. 99; No. 4, p. 259) lists were published of grants to research workers from the Science and Industry Endowment Fund during 1928. The requests for assistance for 1929 have now been considered, and the following grants made:—

Mr. H. R. Carne, for work on caseous lymphadenitis in sheep,; the Rev. Father E. F. Pigot, S.J., for work on solar radiation; Mr. U. M. Trikojus, for investigations in the field of organic chemistry; Dr. G. H. Briggs, for work on alpha rays; Mr. L. W. Phillips, for a study of poison plants; Professor J. C. Earl, for work on *Posidonia* fibre, and the cellulose of certain other fibre plants; Dr. C. S. Hicks, for investigations on thyroid glands; Mr. N. B. Tindale, for entomological investigations; Dr. P. D. F. Murray, for work on the embryo of the chick; Professor A. McAulay, for work on corrosion of metals; Dr. C. Fenner, for physiographic studies; Acting-Professor Bagster, for work on essential oils; Professor Nicholls, for a study of fresh water crustacea; Mr. J. Shearer, for a study of the phenomena of X-ray reflection; Mr. T. Iredale, for work on organic substances containing iodine; Dr. F. Lions, for work in connexion with optically active compounds of certain minerals; Dr. W. Davies, for investigations of stereochemistry of salts of organic bases; Mr. G. D. Osborne, for geological work in the Hunter River valley; Mr. E. E. Kurth, for investigational work on oil shale; Miss Dorothy Hill, for geological investigations of coal fields; Dr. B. Cavanagh, for work in connexion with potentiometric titration; Mr. W. G. Kannuluik, for experiments on thermal conduction; Professor R. D. Watt, for work on soil bacteriology; Miss B. J. Murray for studies of the ecology of arid vegetation; Professor J. T. Flynn, for investigations in connexion with marsupial development; and Dr. J. V. Duhig, for work on protein metabolism.

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